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THE INDUSTRIAL SELF-INSTRUCTOR.

THE

INDUSTRIAL SELF-INSTRUCTOR

AND TECHNICAL JOURNAL.

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WITH PRACTICAL USEFUL AND TECHNICAL NOTES, FACTS, AND FIGURES,
FOR READY REFERENCE.

BY NUMEROUS PRACTICAL WRITERS AND TECHNICAL EXPERTS

WITH

WORKING DRAWINGS, DESIGNS, AND DIAGRAMS.

VOLUME III.

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WARD AND LOCK'S
"TECHNICAL JOURNAL
AND
INDUSTRIAL SELF-INSTRUCTOR."

THE FACTORY OR MILL HAND AS A TECHNICAL WORKER.

THE ORGANISATION, GENERAL DUTIES, AND SPECIAL WORK OF THE STAFF OF FACTORIES FOR THE PRODUCTION OF SPUN AND WOVEN GOODS—THAT IS, "YARN" AND "CLOTH"—AND THOSE CHIEFLY IN COTTON AND WOOL.—GENERAL DESCRIPTION OF THE VARIOUS PROCESSES OF MANUFACTURE.

CHAPTER VIII.

AT the end of last chapter (vol. ii., p. 258), in describing the process of drawing cotton fibres, we observed that if a band or sliver of the fibres pass between two rollers, it leaves them at the same velocity with which it entered. But if it be taken off quicker than it enters, it is stretched in the exact proportion as the velocity at which it enters is to the velocity at which it comes out.

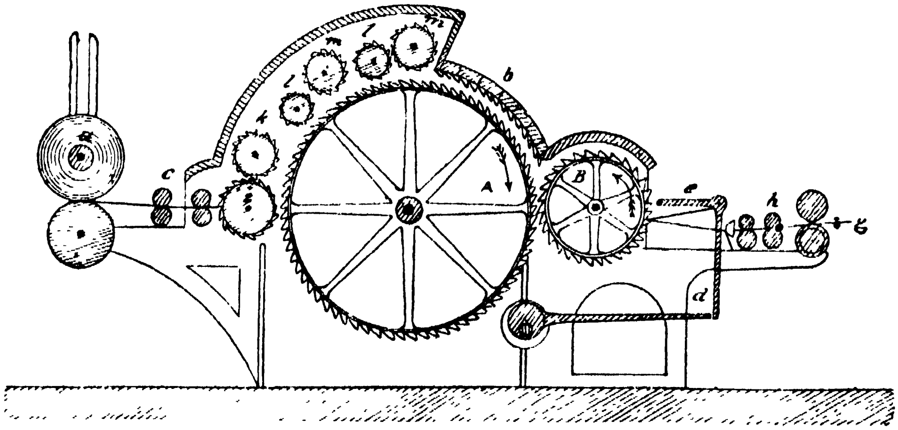


Fig. 5.

In the drawing rollers of the finisher carding engine, fig. 5, the velocity of the pair of rollers nearest *g* is double that of the pair which receive the sliver from the trumpet-mouth delivering point of the carder. Consequently, in passing through, the length of the sliver is doubled.

Generally the slivers, when they come from the rollers *g g*, are led away through a channel, and at the end of it are rolled on rollers (fig. 6), and are afterwards united and made into wider slivers by a doubling engine or lapping machine, like the one shown in the illustration.

These lap rolls, *a*, are brought to the finisher carding engine (fig. 5), and taken up by a double pair of grooved feeding rollers, *c*, the first pair of which revolve slower than the second in the ratio of 10 to 13. From these rollers the cotton is conveyed by the roller *i* to the drum A and the roller *k*, between which it is worked up. Situated higher up are two more rollers, *m, m*, and two strippers, *l, l*, which, together with the drum A, work up the cotton exactly in the same manner as at *k*. The remainder of the drum is covered in, and the doffer B performs the same functions as in the breaker carding engine. The cotton (or web, or fleece as it is now called) is taken off by the doffer knife *d e*, and is ready for the "drawing frame," which will be described in a succeeding paragraph.

Stripping or Self-Cleaning Carding Engine.

From time to time the carding-cloth on the drum and case must be cleaned, and the teeth sharpened so as to exhibit a uniformly curved surface.

The sharpening is generally done by emery powder, and the cleaning is performed by combing or by the hand, or else by an arrangement in the engine itself. A carding engine with a mechanical arrangement for cleaning the case (automatic carding engine) is that by Dobson & Barlow, of Bolton.

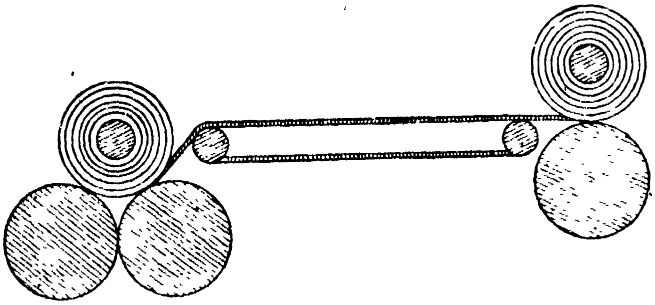


Fig 6.

The principle of these different engines is in so far similar, that the covers lift up in a certain order, and a cleaning board with a soft covering is pushed under and removes the waste cotton. The cut, fig. 7, shows a machine in which all the covers are opened and cleaned the same number of times—2, 4, 6, 8, 10, when the cleaner is going forward, and 1, 3, 5, 7, 9 when it is returning. However, in another form of machine the first set of lids is raised twice as often as the second; thus: 2, 4, 6, 10, 14, and 13, 9, 5, 3, 1; then 2, 4, 6, 12, and 11, 7, 5, 3, 1. Thus the first six covers are each raised twice, whilst the second eight are only being raised once. The operation of cleaning is divided between the forward or backward moving of the cleaning appliance, the lifting up of the lids, and the actual cleaning itself. The drum *a* (fig. 7), moved by an endless band, carries the arm A, and is inside the carding drum. To this arm is attached a frame, and to the latter is bolted an upper cross-piece, *b*; the cross-piece carries a toothed wheel, *c*, which works in the segment B, toothed on both sides, and fastened to the case of the drum. From the drum the motion is carried by the cord 1 to 2, and by the tooth wheels 3 and 4 and 5 to the larger wheel toothed on both sides, and which work in the wheel *c*. It is now evident that each revolution of the toothed wheels causes a simultaneous revolution, *a* and *c*, and by the working of the wheel *c* on the segment B the movement of the cleaning apparatus is produced.

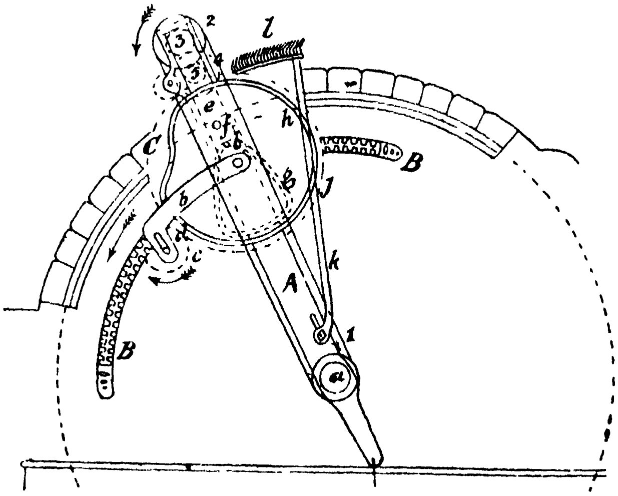


Fig. 7.

When the wheel *c* arrives at the end of the segment B, it turns round to the upper side and moves the cleaner in the opposite direction. This is aided by a finger working on *f*.

The even raising of the covers on their ends is caused by the apparatus working on both sides of the machine. But, on the other side, the motion is not caused by a drum, but by a motion connected with the wheel 5.

The opening of the covers is caused by thepusher *e* working in a slit of the arm A. The corners or noses of the pusher catch under the ends of the lids and lift them up when the covers *g* in the wheels *c* are in the opposite position to that shown in the sketch, and move the pusher by means of a nipple. The closing of the covers is caused by a small spring fastened in their backs.

THE ORNAMENTAL DRAUGHTSMAN.

HIS STUDY AND THE DETAILS OF ITS PRACTICE, CHIEFLY IN RELATION TO TECHNICAL WORK IN MANUFACTURING DESIGN.

CHAPTER XVI.

The first point that we shall attempt to illustrate is the completeness of Nature's expressional power. About her way of showing her meanings there is no appearance of rude hurry, no traces of confused incompleteness. Everything is done after the most careful fashion; and her general plans, her main ideas, perfect though they be, are never allowed to interfere with the entireness, in every point, of her minutest detail. The mountain, the shadow of which throws darkness upon the earth for miles beyond its base, may be purple-clad with heather, whose every bell shall have beauties far beyond discovery by the keenest vision. The ocean, which stretches away on all sides illimitably, might employ the power of the noblest painter to express the measureless meaning of a single yard of its surface. No deficiency, no random purposeless lines, no uncertain wavering tints, no miserable attempts to fill up a landscape with foolish falsehood, or practising of ignoble "economy" in any kind of expressional effort, are ever found in nature. Now, apply this principle to the method of drawing or painting. In the artistic compositions, everything therein will be complete. The strokes will all have their meaning, distinct, decided, indisputable. Every form, whether it be animal, vegetable, or mineral, cloud-flakes, coast-shadows, and ocean-foam, will be complete, entire, perfect. No shuffling, no evasion, no laziness, but a straightforward looking at all the facts of the drawing or picture, and a rendering of them after the fullest fashion consistent with nobleness and truthfulness. An honest method of work this; indeed, the only honest method. One of the greatest mistakes which students commit is to believe that the valuable may be obtained without some equivalent at all, generally. Practically, in a thousand ways, we throw in seed by the wayside, and fold our arms contentedly, lolling out the summer, and hoping that things "will come right in the end." But when the "harvest time is gone and the summer ended" we shall find, alas! that whatever reaping there has been for some, there has been none for us—save the sorest of all reapings, the saddest of all sowings, that of the whirlwind and the wind. Nature is no niggard in the bounties she offers, she is the freest of all givers; but we must go to get her gifts, and both the going and the getting speak of labour, not seldom of pain, although in very truth he who goes will find in his getting how true it is—to quote the fine language of that Book where the finest language is embodied in the most beautiful and suggestive of similes—that he who "now goeth forth on his way weeping and beareth good seed, shall doubtless come again with joy and bring his sheaves with him." And, in sober fact, the artist who is true to his vocation—and that he is sure to be if he be true to himself—will find not seldom that he will go forth to his labours sorrowing. For it is only the inept or the conceited who is satisfied with his work. The true artist is ever "sighing for his ideal." It is not given to him to be satisfied with his work. Work, indeed, considered as a thing done, and done well—the only true and honest conception of work, be it noted—is what he never feels that he has done. At the best he has but honestly attempted to do his best. For, as one of the greatest —greatest because so morally and religiously noble in his thoughts—of our authors has finely said, as the schemes and hopes of the brain go fast and far ahead of the dexterity of the hands or the nimbleness of the feet, so the true artist ever finds that his high and noblest conceptions of art are but rarely, if ever, realised; that the height he vainly hopes to reach to-morrow he finds to be but a vantage-point from which he sees but too clearly that the point he aimed at is unfortunately higher than he thought of. But the true artist, like the true man, is not daunted by difficulties, sitting to cry over them as they surround or lie before him. They are things but to be overcome. So that is all, and so much in sober practicality is it, that should any of our students conceive success will be obtained without his realising it, he will be sorely disappointed. Should, indeed, he be inclined to be daunted by it, and not possessed of the bravery to meet it, the best counsel we can give him is to throw up his pencil and "try some other trade."

We have said that the artist must go to nature for his best teachings. This, however, does not preclude, as some might deem it does, his going also to the "works" of artists who have gone before him, or who are his contemporaries. The true and the good amongst these are worthy of being set up as teachers. For they who did those works have done the same thing we here write about. They have been to Nature's school, and it is only in so far as they have been apt and willing scholars that what they have done is good. Nature, as we have said, is infinite in the variety and the fulness of her expressional power. The fields for the display and the study of this are as wide as they are endless and inexhaustible. Even so, and that in almost the smallest of her subjects. There is a year's study in a group of stones lying on the face of some precipice, which have been weathered by the storms and the sunshine of centuries; a year, indeed, would not exhaust the beauty of that which might be covered with your extended hands. Artists have been known to spend year after year in some favourite spot, the area of which might be measured by a pebble cast from a strong man's hand, till after they had become grey-headed in the loving service they have confessed that, so far from having exhausted the beauties or learned all the lessons which they could give, they had only begun to discover how infinite and inexhaustible they were. A young artist will learn much—it is not given to any one that he should learn all—from an hour or two's study of the clouds. Let him lie down on some fine, warm, genial May day, or in the "leafy month of June," when the very air he breathes is, as Hawthorne says, "something to thank God for," and look up into the sky. Let him honestly, in a loving, trusting, spirit, try to see as truly as he can what is spread out before him. And if he does not rise from this patient study with some conviction of the truth that he had till then not even a faint conception of what the clouds show and teach, we shall be much surprised. Nor will he be henceforth surprised when he hears on all sides of him the popular expression of opinion as to what cloudland and its glories are, for he will then have a knowledge of his own previous ignorance to fall back upon to explain the reason. And assuredly he will have learned how exhaustless of artistic lessons this much-neglected region of wondrous beauty is. Nor, in referring him to this region of study, do we lose sight of what "old mother earth" can teach. Neither is the student, who takes to the study of the sky to learn somewhat of the mysteries of the "balancing" of its clouds, at all likely to lose sight of or interest in the green fields below them, over which in sunshine they cast their wondrous shadows. It is not given to every student to travel far to study the grandest of natural scenery; but, as we have already hinted at, he will in the confined limits of even a by no means picturesque locality in which he may reside, find enough to teach him lessons applicable to his art. Indeed, if he could feel assured that he could master all the lessons yielded by a short stretch of country lane, or strip of hedgerow and fence bottom, or failing that, but some tiny plot of town or suburban garden, he might well congratulate himself on the acquisition of his treasures.

Nor let it for a moment be supposed that this study of nature in the widest, and failing that in any narrower aspect, which an art student can command, is only to be followed by those who design to follow out what is supposed to be that profession to which the name of "artist" is alone to be applied. There is no mistake which has been made in all matters connected with art, which has been so pregnant with real mischief as this idea, that it is only this class of artist—the painter of pictures popularly so called—who has any lessons to learn from a study of nature. This crude notion it was which, more than anything else, brought about that almost utter absence of artistic feeling and expression in the popular mind, which was our national characteristic even at a period so recent as some quarter of a century ago. Nor need this popular belief be at all matter of surprise, when we recollect that there were scarcely any of those actually concerned in the designing and manufacture of various objects, who had the remotest idea of the benefit they would receive from the study of nature. It was only the other day that one who has done in his own particular line of art-manufacture more than any one to release it from the reproach, all too well founded, under which it so long laboured, earnestly advised all connected with his business to go to nature as being the best, indeed, the only place, where lessons applicable to true art could be learned. Nor did this ignore the value of or lessen the importance of study of the works of the best masters of design, in ancient, mediæval and modern times; for the best of those masterpieces were the work of men who loved nature best and studied most. Nor was the advice this able authority gave confined, or only suitable, to those connected with his own branch; it was, and is, applicable to all other branches of art-manufacture. And it is to the wider study and closer love of Nature in all her glorious manifestations—alike glorious in the grandest stretch of wildest forest scenery as in the tiny flower which peeps from beneath a stone or waves in the winds which gently sweep the banks of our country roads—that we owe the fact that we have now manufactures to which, in some at least of their works, the term "art" may with truth be applied. In more than one of the chapters yet to come under various headings in our Journal, particularly in some of those treating of special branches of art-manufacture, occasion will be had to enforce and illustrate this statement.

We have now brought our pupil reader to a point in his progress as a draughtsman where he at least knows what he ought to do in order to have the power to execute what is called "outline" work, and this either in copying from the works of others or committing to paper his own conceptions of ornamental form, or to take representations of objects which abound in an infinite variety of lines in combination from the inexhaustible resources which nature opens up to him. The pupil reader may not be able at this stage of his progress to do all this work, or any one part of it, with facility and accuracy, but these will come with careful and conscientious practice. How to study and how to practise we have endeavoured to show, and this with at least an earnest desire to be honest with our pupil readers, and that, in their study and practice alike, they should be honest to and with themselves. There is very much in the phrase "conscientious work," and without it but little true progress will be made.

THE TECHNICAL STUDENT'S INTRODUCTION TO THE GENERAL PRINCIPLES OF MECHANICS.

LAWS AFFECTING NATURAL PHENOMENA—MATTER AND MOTION.

CHAPTER XVII.

AT the conclusion of last chapter we stated that if we knew the momentum of a body, we had the measure of the force which produced it. A man will move a heavy load with such difficulty that its speed or motion along the ground may be very small—say, represented by one foot per second: he moves half the load with so much greater ease that he can move along, and in the same degree make the mass move with him, at the rate of two feet per second; while he may have a weight so small that the speed of its motion will be represented by his walking quickly, if not absolutely running, as he drags after or pushes before him the weight,—but the quantity of the motion or the momentum may be the same, and in all the three cases the true measure of the force which produced the motion. Taking the case illustrated in preceding paragraph, of the two balls one of 2 lb. and the other of 224 lb., if these are found to move at the same velocity, by the different quantities of motion in each we have an indication of the different forces which were required to move the ball. But the light ball and the heavy ball, if moved by a force equal in both cases, must have, as we have seen, different velocities: a ball of 1 oz. in weight impelled by a given force has a velocity sixteen times as great as a ball impelled by the same force weighing 1 lb. or 16 oz.

Arresting the Motion or Resisting the Momentum of Moving Bodies.

But, as we have just seen that, to get great velocities in moving bodies, or, to use the common well-known expression, to "get up the speed," we require the continued action of the force,—so, in order to reduce the speed of a moving body and to bring it to rest, we must have the same amount of force which was required to produce the motion or speed. Thus, if a certain force be required to be put forth in turning a grindstone to bring it up to a given speed, the same must be exerted in order to bring it to rest. But in accordance with what has been already stated as to the laws affecting the rest and motion of bodies, the sudden stoppage of a moving body, or in other words the destruction, so to say, of its momentum, causes shocks and strains which may be, and often are, productive of great mischief and loss. Thus the strain on the arm, and the shock through it given to the body, by stopping the motion of the grinding stone at once, would be so great in the case of a large and heavy stone, that a serious injury to the muscles might result; but the momentum might be so great that the workman might not have strength enough to stop the revolutions at once. In such a case "nature," so to say—although others would express it "common sense"—would prompt the workman so to apply his strength as to allow the motion of the grindstone to be reduced gradually. This he in fact does intuitively, this principle being exemplified in a number of instances in mechanical work. In the mechanism known as the "friction brake," or simply the "brake," by which the motion of revolution of a shaft, etc., is stopped, the power of the brake is applied gradually: if put on to its full power at once, as it might be by means powerful enough, the motion of the machine would be stopped, but another result would probably be obtained, not desirable—namely, the sudden breakage of the part or of several parts. Soft and movable a substance as common air is, it may be adapted to act as a brake by gradually compressing it in a closed vessel. Many other illustrations of this law will present themselves to the mind of the thoughtful and observant student.

Exemplifications of the Foregoing Principles found in Mechanical Contrivances.—Hand Appliances.—The Hammer.

This property of bodies acquiring momentum when in motion, and in proportion to their speed and mass—so that a heavy body will at the same speed have a much greater force or power of or through momentum than a small body, just as a light body will have a a greater force of momentum if its speed be great—is of the greatest practical value in mechanical work. It is exemplified in the simplest of all mechanical work—the driving of a nail into wood or other substance. By pressing the surface of the "hammer" merely on the top of the nail, strength of the arm applied through the fingers might, in the case of a short nail and very soft wood, succeed in getting the nail pressed into the substance. If the operation succeeded, the process would in any case be a slow one, while in the majority of cases it would not succeed at all. But by raising the hammer a short distance above the head of the nail, and bringing it quickly down upon it, the momentum acquired by the velocity and the weight of the muscular force of the arm and wrist will drive the nail quickly in. The driving may take a succession of strokes, or it may be driven in by one stroke, according to circumstances. And in no work done by man is the wonderful power of volition or will possessed by him so beautifully illustrated as in this very process of nail driving; the degree or amount of momentum required by an infinitely varying order of circumstances being given to the hammer as it is required, and all the varying shades, so to say, to all of them being given or obtained so intuitively that the workman is not aware that he is going through processes of such wonderful nicety of adaptation. And in the application of such a force as that of steam to the work of hammering, we have a striking exemplification in the steam "hammer" of what mechanical skill, aided by close observation of facts existing around us, can do in giving the mechanic an apparatus which almost rivals the human arm in the nice adaptation of its power to the work to be done,—an adaptation with such a wide range that the steam hammer will "drive a tack," break the shell without destroying the kernel of a hazel nut, or weld and forge into shape the most ponderous masses of glowing steel or iron.

Mechanical Exemplifications of the Principles of Momentum (*continued*).—The Fly-wheel.

One of the most familiar exemplifications of the value to the mechanic of this property of momentum is the "fly-wheel." This contrivance is adopted in cases where there is a varying force or a rapid succession of forces exerted, so that continuity of motion is obtained. Without it, the motion of the machines would be in a succession of jerks, or in some cases a complete cessation at certain points. Thus, in the case of a man turning a crank-handle, he exerts a force so irregular, in virtue of the peculiarity of the crank motion, that while at one point he may be exerting a certain and his full force, at another point he will only be giving out less than half of this; and as in some work the resistance it offers is greater than the power the minimum force exerted is able to overcome, the man would not be able to do the work at all. But by adopting a fly-wheel, which is practically a heavy "mass" capable of revolving along with the crank-shaft or spindle, the power given at the maximum point, where the man's force is greatest, imparts an increased velocity, and therefore increased momentum to the fly-wheel; so that when in the course of turning the handle or crank the man is putting out his least or minimum force, the momentum acquired by the mass of the fly-wheel carries it past this weakest point and forward to that at which the greatest force is exerted. The most striking and the most familiar exemplification of the value of the "fly-wheel" is met with in the ordinary or reciprocating form of the steam engine. In this the motion of the piston in one direction in the cylinder must be gradually stopped, and then actually reversed or made to travel in the opposite direction. Before this reversal of direction of motion can possibly take place, it is obvious that at the point where the change is to take place the piston motion must absolutely cease, and this point is at both ends of the cylinder. These two points are known as the "dead points"—a phrase expressive of the fact that the power or repulsive force of the steam is no longer active or alive in giving motion to the piston and to the crank-shaft to which its motion is communicated, so that without the adaptation of the "fly-wheel," motion of the engine would not only cease, but the momentum acquired by the piston in its path in the cylinder would have the tendency to knock out the cylinder cover at the end. But by the increased velocity given to the fly-wheel when the steam is giving out its full power, it acquires such a momentum that it carries the crank past its "dead" points, which correspond to the "dead points" of the piston motion. It is by thus acquiring force or momentum that a fly-wheel is useful in certain work, as in the cutting of substances such as straw or hay, the character of which varies, presenting at one time a mass of material easy and at another difficult to be cut. When the difficult parts come up—which may therefore be considered as obstructions—the momentum acquired by the fly-wheel during the periods when the work is easy carries it past or gets rid of the obstructions—in other words, cuts the less easy yielding substance, and thus a uniformity of motion and work is obtained. In looking at the work or use of the fly-wheel the youthful mechanic is apt to make a great mistake in relation to it, and to decide that it must be a contrivance to create power. The truth is, that many working machinists who cannot claim to be youthful, at least in regard to age, do hold this belief and apply the notion that machines do or can create or make power; we shall see, however, as we proceed in further examining the peculiarities and properties of bodies in motion, that this is actually erroneous, and that it gives rise, when held, to the gravest of mechanical errors. And we shall see still more closely, what has already been alluded generally to, that machines are adaptations of mechanical or concrete bodies by which extraneous forces within the reach of man are made capable of doing certain work, and that this machine is simply the vehicle, so to say, by which we apply the given force, which can in no case be added to by any mechanical arrangement—that is, no force can be created by a machine or by any mechanical arrangement. Rather, as we shall see, on the contrary much of the force is lost by the use of the machine. In the case of the fly-wheel it creates no power; it can and does give out that only which it receives, and it requires the same primary force to give it the force of momentum which it receives and which it gives out or imparts to the machine. In other and familiar words, it gives back to the machine, at a period in its working when it needs some extra force to overcome a new obstruction or some greater work to be done, the force which it received at a period in its working when it had some force, so to say, to spare.

Further Exemplifications of the Principle of Momentum—Springs to Carts and Carriages.

There are various other expedients and contrivances met with in practical mechanics in which the property of momentum plays an important part.

Thus "springs" may be said to be fly-wheels dealing with momentum, but only in the opposite or converse way. They receive—as for example by the shock given to a cart when the wheel passes over an obstruction which it does not crush, but falls, so to say, on the other side with a jerk or shock—a certain amount of momentum, which, if communicated at once or directly to the body of the cart, would tend to, if it did not actually, injure its parts, or (what would perhaps be of greater pecuniary moment) its valuable contents. But this momentum the spring receives and stores up, so to say, as the fly-wheel stores up its communicated or acquired momentum, and gives it out gradually to the body of the cart. So in the spring safety valve of the steam-engine boiler, the violent oscillations which would result if it received directly the varying yet powerful impulses of the steam are controlled, and equalised, so to say, by the spring taking up the force or momentum and giving it out gradually. This equalising effect, obtained by what may be, and is popularly, called the "yielding" or "give-and-take" action of the spring, is perceived in other machines and expedients. Thus, if a rope attached to a vessel with considerable "way" or "weigh" or motion in it, and possessed, therefore, of a great momentum from its huge mass, be wound once round a strongly fixed post on the quay, by allowing the rope to slip and pay out as it tightens, the momentum of the vessel will be gradually overcome, and it will be "brought up" or to a stand-still, when the same rope would be snapped like a rush or thread if the strain were allowed to be put on it all at once. Its own elasticity, together with its occasional slips, allows the strain to be put on gradually. In the same way an elastic cord or hempen rope will resist without breaking a weight suddenly dropped—as for example heavy bodies dropped into a scale—which would overcome and break a metal rod or wire much stronger in itself than the elastic cord or hempen rope, and for this reason: the elasticity of the rope, the capability of its fibres to stretch, would give out its resistance through a greater space, and therefore during a greater length of time, so that the momentum is overcome gradually, or is, so to say, absorbed by the fibres of the cord. All the effects of the various mechanical expedients classed by the engineer under the general name of "cushioning" come under the same law, and exemplify methods of meeting the same property of moving bodies, or of momentum; and engineers of large and wide experience have some curious and most suggestive incidents in their working life to relate, in which, by a careful adaptation of the principle, serious accidents have been prevented. The phenomena of accelerated motion, to which reference has already been made, come in to modify the effects of momentum. A small body moving quickly will have more momentum than a larger body moving slowly; and how momentum of a moving body may be greatly increased by increasing its velocity is exemplified in the case of a small ball, as say a rifle ball. This, if thrown by a man with all the force of his arm, while it would not penetrate and pass through a thick pane of plate glass, when it is projected from the rifle itself at an exceedingly high velocity, due to the explosive or repulsive force of the gunpowder, would pass through with ease a plank of timber of considerable thickness. This property of increase of the force of momentum in a moving body of a given weight in proportion as its velocity is increased is usefully applied in many cases of mechanical work. The "piling" engine, by which wooden or other piles are driven into soil in order to obtain firm foundations for superstructures raised upon it, or for inclosing spaces, etc., depends upon the property of the momentum of a weight falling through a vertical space, it acting in the same way as a hammer driving a nail. The necessary power may be obtained either by having an exceedingly heavy weight falling through a comparatively short distance, or a smaller weight falling through a much longer distance. The student will perceive that in practice it will be much more convenient, and the desired range of effective blows or impacts upon the pile will be obtained with greater mechanical ease, by having a comparatively light "monkey" or driving weight to deal with, than by having a very massive and therefore less easily handled weight. Now the law or property we have already named at the beginning of this paragraph comes in to aid the working of the piling engine or pile driver. We have seen, in the paragraphs treating on gravitation, that the motion of a falling body is an accelerated one, and that the accelerated force of a mass is as the space or distance through which it falls or passes multiplied by the weight or mass; and the effect of a force is equal to the mass or weight multiplied by the accelerating force. The momentum or moving force of two bodies is as the weights multiplied by the speed or the velocities arrived a in equal times. To put it another way, the momentums—if we can use the plural of such a term—of any two bodies passing or falling through equal distances are as the squares of their velocity due to this equal extent of drop or fall multiplied by their masses. Suppose, therefore, that we have a given weight of a cast iron or steel ball to do a variety of work, say in smashing up metal or other substances, which is used by allowing it to drop from a height in the way known in all iron foundries, we can with the same uniform weight get a wide range of breaking force or momentum simply by altering the height from which the ball falls; and we can easily calculate the amount of the breaking force or the pressure which it will exert upon the mass or substance on which it falls at the moment of coming in contact. By the law we have already explained, we can find the velocity which is due to the ball falling a certain height; and, presuming this to be 64 lb., and the weight of the ball half a hundredweight, we have 64 × 56 = 3584 lb. as the momentum or moving force. And, based upon the truths stated above, we can in like manner calculate the different effects of different heights with the same ball. If, for example, we have a given weight, and we wish it to have a double momentum or striking effect, we must give it a double speed. Thus, suppose we have a weight of 2 cwt., and with it to give the momentum or striking effect of 4 cwt., and that this effect is obtained by the velocity due to the ball falling through a height of 5 ft.: to give a double velocity to the 2 cwt. we multiply this into itself, and this again by the height of the heaving body to obtain the height from which to drop the ball,—thus 2 × 2 × 5 = 20 feet, which will give to the ball of 224 lb. the momentum or breaking effect of one of 448 lb.

Importance of the Points involved in the Principle of Momentum to the Mechanic.—Practical Examples.

From what we have said in preceding paragraphs under the head of "Momentum," the youthful student of the principles of mechanics should be able to perceive something of the wide range of its practical applications to mechanical work, and how the value of this will be dependent upon the way the laws which govern this property of bodies are applied to its general design and its various details. And so far as this property relates, so to say, to what may be called striking forces, the student should be able now to see that in relation to given masses, bodies or weight (to use the common term, which gives in reality the most tangible and practical idea of them), the time during which and the space or distance through which these weights are under the influence of any force—be it that of gravity or of human muscles, etc.—are important elements in obtaining an increase of effect or of power in doing the work for which the weight is used and the force applied to it. A man with a given weight of hammer with a short swing incapable, so to say, of doing a certain work, such as driving a nail into a denser piece of timber, or as breaking up a piece of metal, gives to his arm a wider swing, and finds then that his light hammer does the work of a heavier one. He does this intuitively, and may have no conception upon what the increased power depends. The hammer has, in coming in contact with the nail-head to be driven, or the metal to be smashed up, the concentrated effect both of gravity and the muscular force of the arm; and by giving a wider swing to this, not only is greater time taken, but greater space or distance passed through, given, by which those forces are allowed to act, and so have increased effect. That the useful effect of a force is to be estimated as much by the influence of time and space during and through which the power or force acts as by the primary intensity of the force, is proved by many circumstances in connection with mechanical work. It would convey a few lessons on this important point if the young student were to experiment with a hammer used under a variety of circumstances. Thus, this increase of force through increase of time and space is the principle or property of bodies upon which depend many of the operations of the machine-shop. Thus we can operate upon and produce an effect upon very hard metals by substances in themselves very much softer—as by polishing a steel surface even by a piece of wood, either the steel or the wood surface having a high velocity given to it while the object is at rest. And the same effect may be and is obtained by the use of a very soft polishing powder; and the effect in both cases, just as in the case of a revolving disc of soft wrought iron having an enormous velocity cutting through a bar of steel as easily as cherries or an apple with a knife, is due to the high velocity or speed of the particles. No doubt, in some of such cases another property of bodies in motion yet to be explained—friction— comes into play, but the effects named are obtained chiefly in the way stated. Many other examples might be added, in illustration of the influence of time and space in or upon forces. One is met with in the foundation of the heavy steam hammer. If the full force of such a heavy blow were transmitted through the medium of the anvil directly to the soil upon which the hammer is placed, no site, however naturally strong and able to resist blows, could stand irrespective altogether of the effects, some of which will be noticed hereafter in the proper place. But an anvil rests upon a foundation composed of a combination more or less complicated of timber, and those upon a bed more or less thick of concrete. The effect of this arrangement is precisely the same as shown in that of the trick which, if not now, was used in former days to create the astonishment of a gaping audience at country fairs, in which a heavy anvil laid upon the chest of a prostrate man received blows from a sledge-hammer wielded vigorously by his companion. What seemed in the minds of the uneducated spectators to add only to the danger in which the man lay—namely, the heavy anvil resting on his chest—constituted in fact his very safety; and in like manner the mechanical integrity or "working life" of the steam hammer is secured by the means we have described. In both cases the mass of the anvil receives the full force of the blow, and the force of this is so diffused, so to say, through, or absorbed by, the mass, that the velocity at its lower part is reduced to a comparative trifle.

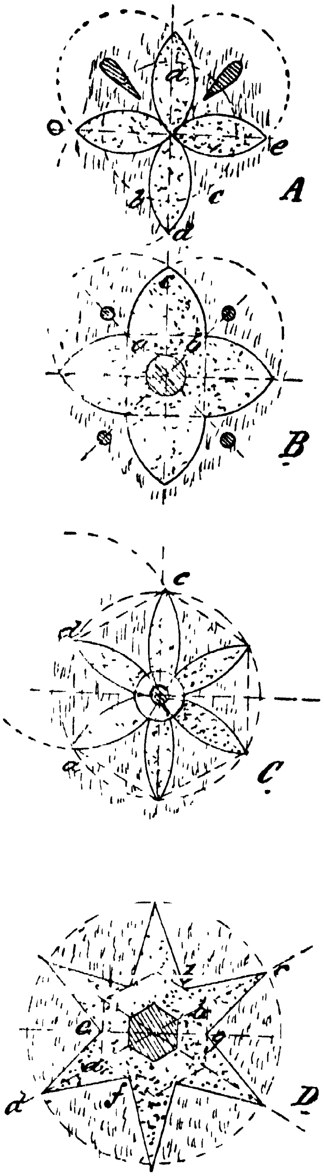


Fig. 1

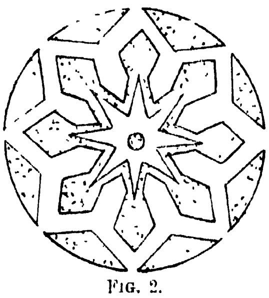


Fig. 2.

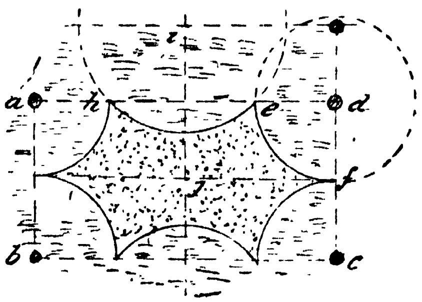


Fig 3

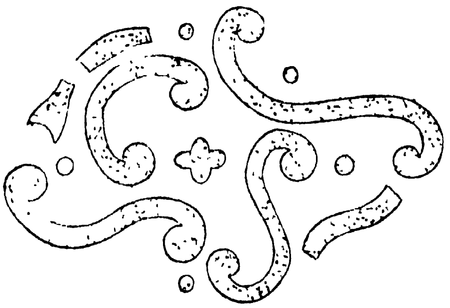


Fig. 4.

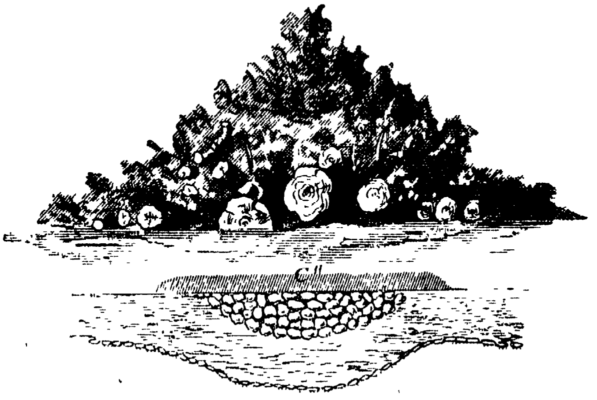


Fig. 5.

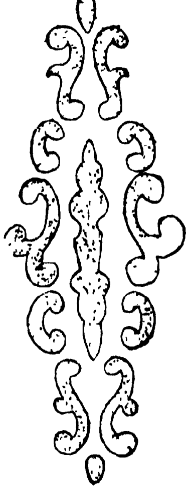
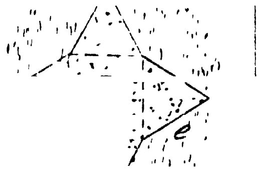
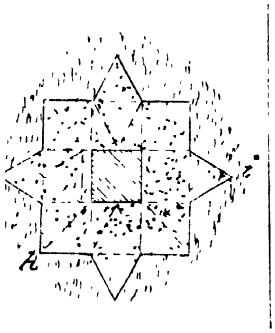
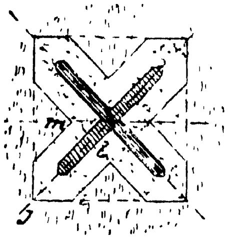
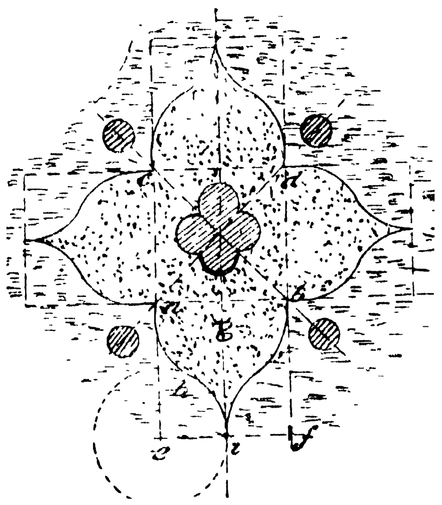


Fig. 6.









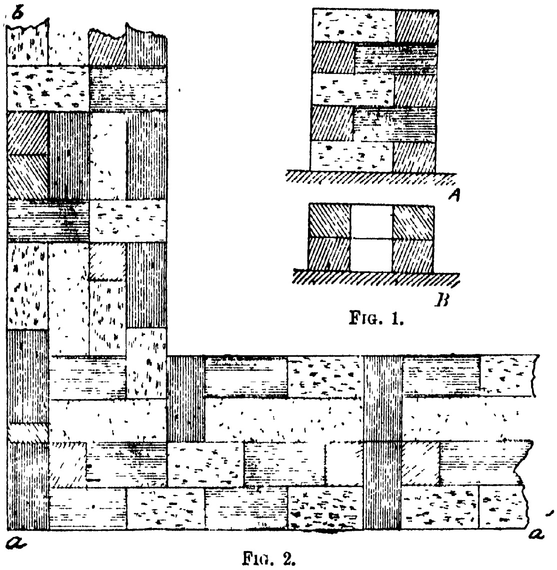
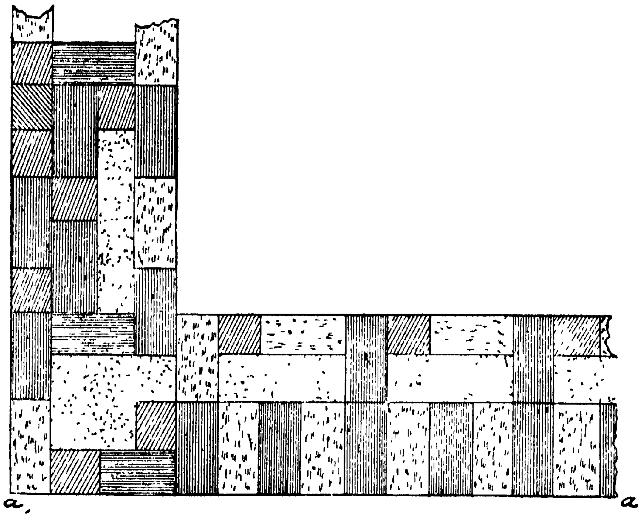


FIG. 2.

FIG. 1.



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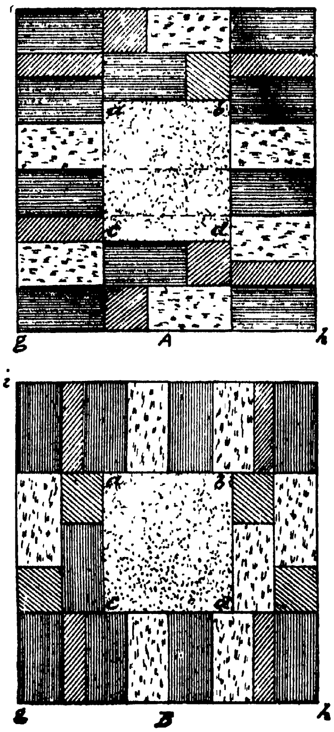

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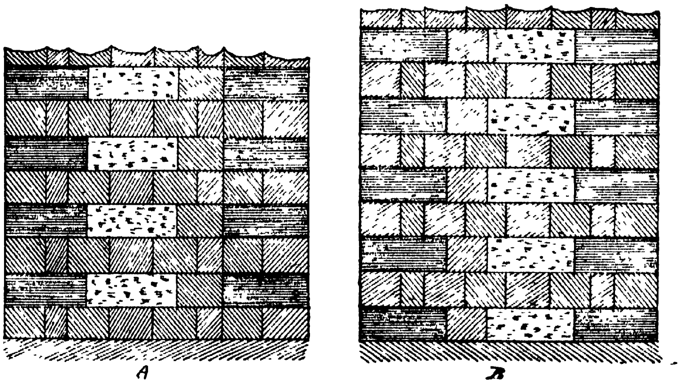


FIG. 5.

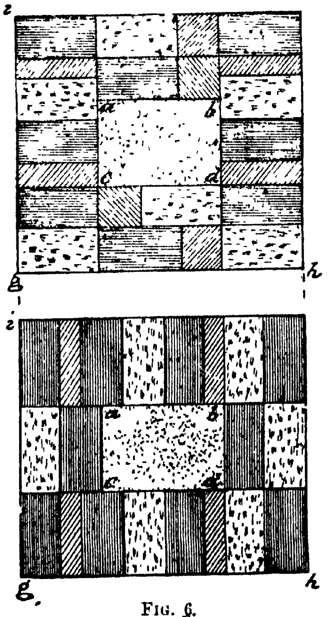


FIG. 6.

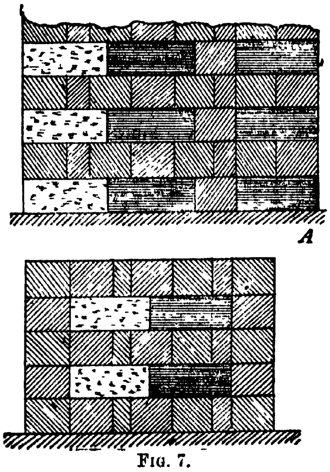


FIG. 7.

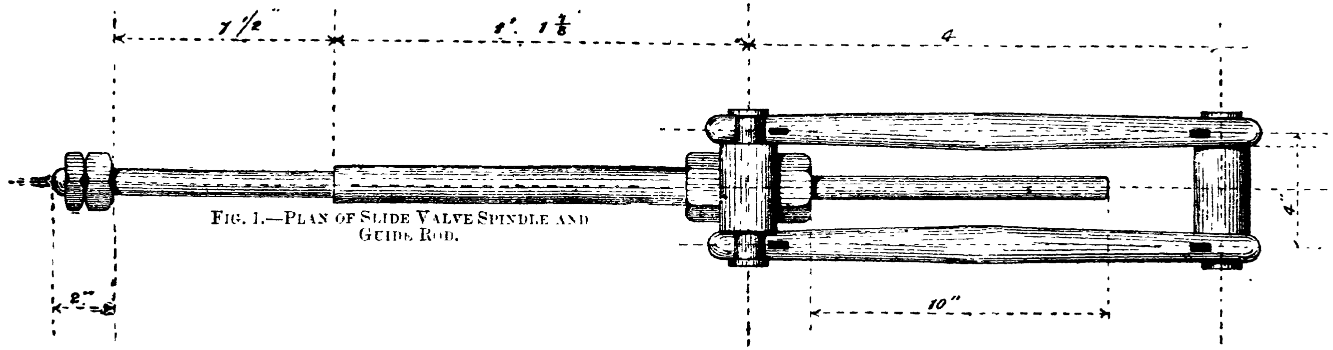


Fig. 1.—Plan of Slide Valve Spindle and Guide Rod.

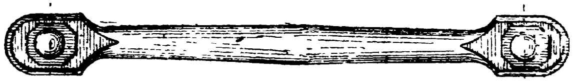


Fig. 5.—Guide Rod for Fig. 1.

(Scale for all the Drawings, 2 inches to the Foot.)

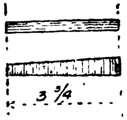
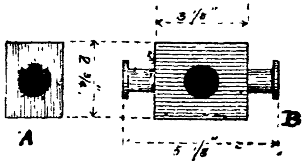


Fig. 4.—Key or Cottar for Fig. 3.



2 —B. Side Elevation of Block for Slide Valve Spindle, Fig. 1. A. Plan of Ditto.

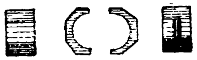
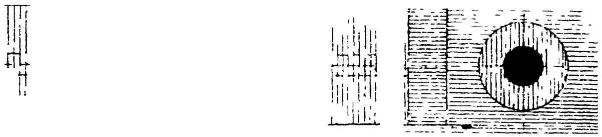


Fig. 3.—Bushes for Valve Spindle (Fig. 5) and Guide Rod (Fig. 1).



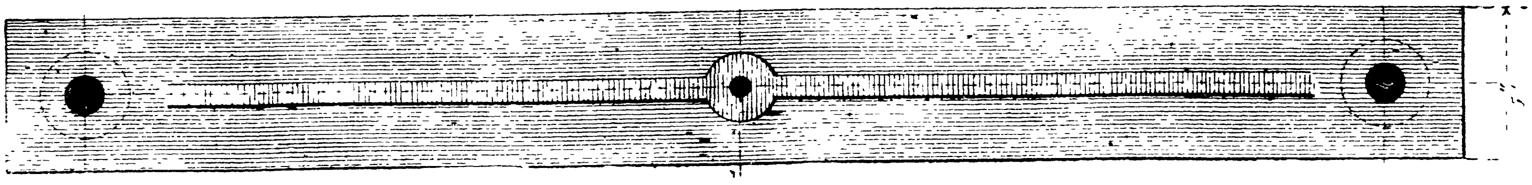


Fig. 6.—Plan of Outside of Top Bar or Guide Bar of Guide Block of Piston Rod Motion (see Figs. in Plate CLIII.

THE GEOMETRICAL DRAUGHTSMAN (*see Text*).

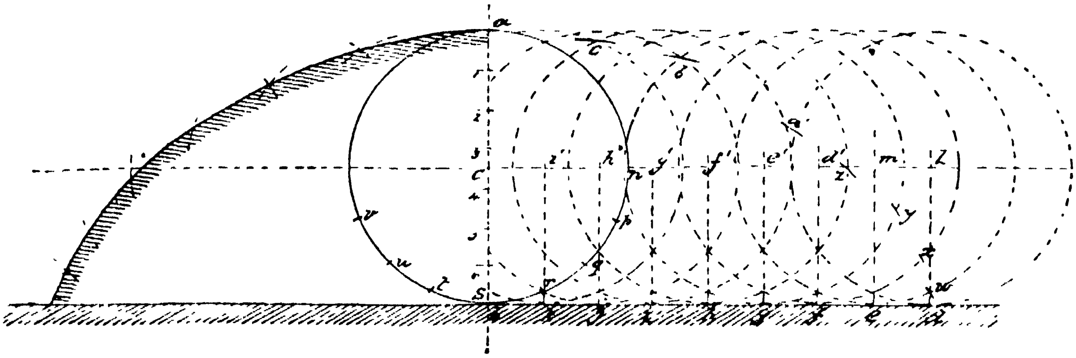


FIG. 1.

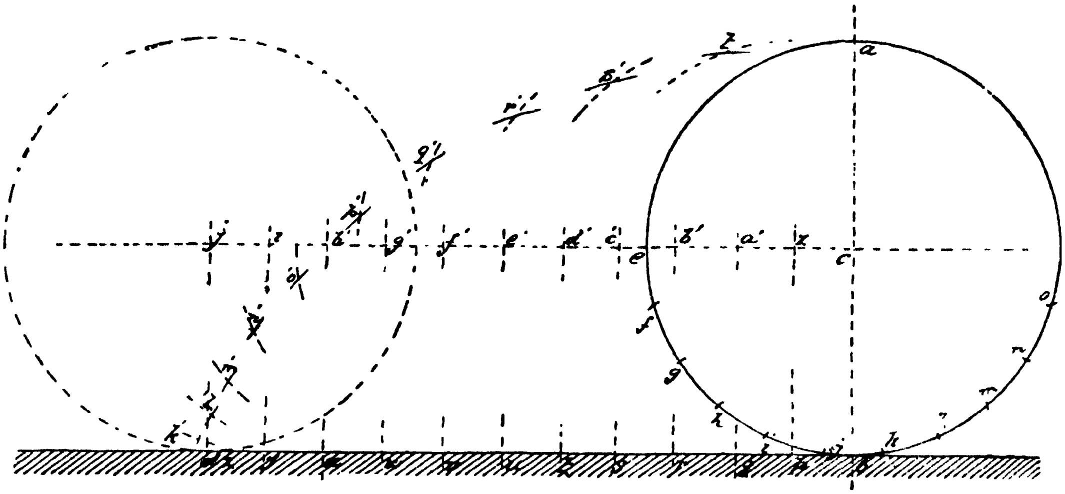


FIG. 2.

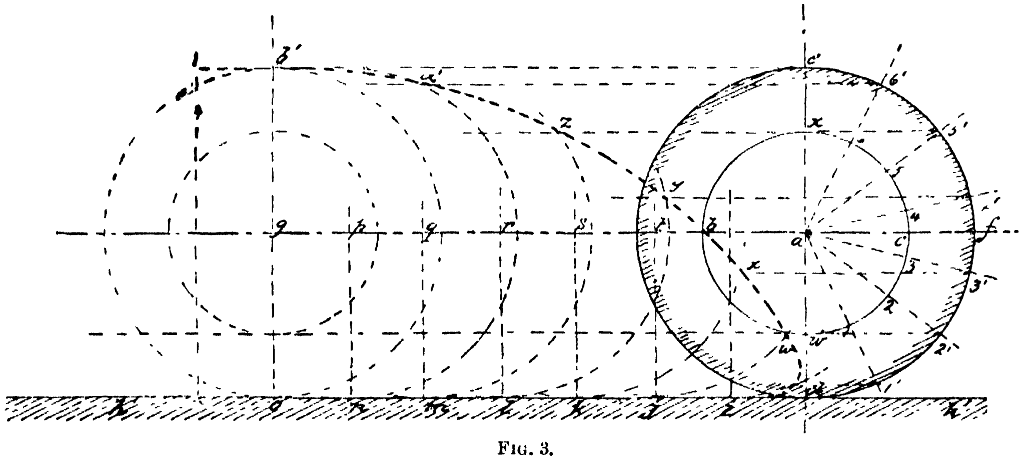
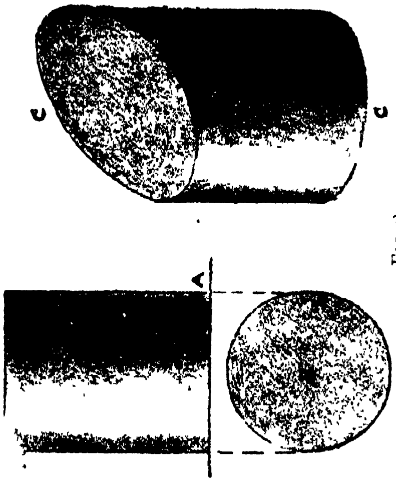


FIG. 3.

THE GEOMETRICAL DRAUGHTSMAN *(see Text).*

SOLID GEOMETRY.



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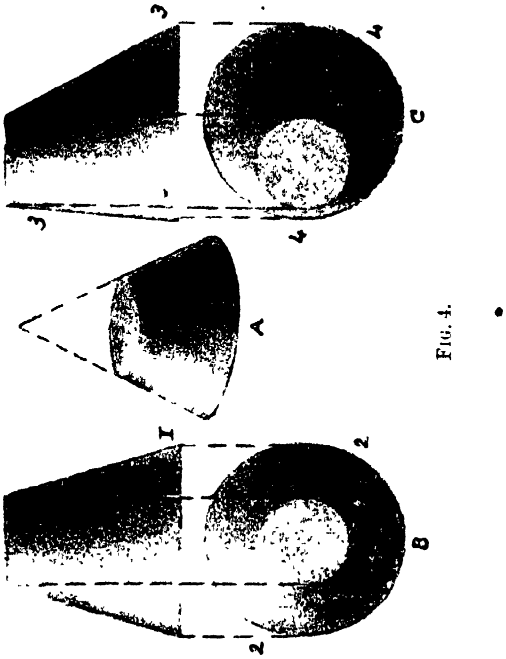


FIG. 4.

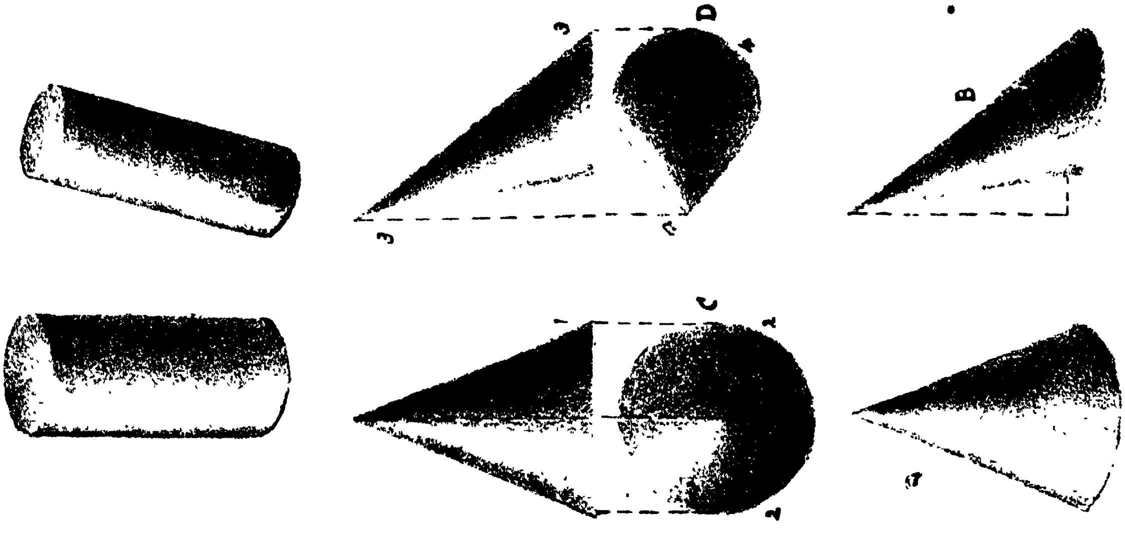


FIG. 3

THE YOUNG ARCHITECT.—*WORKING DRAWINGS* (*see Text*).

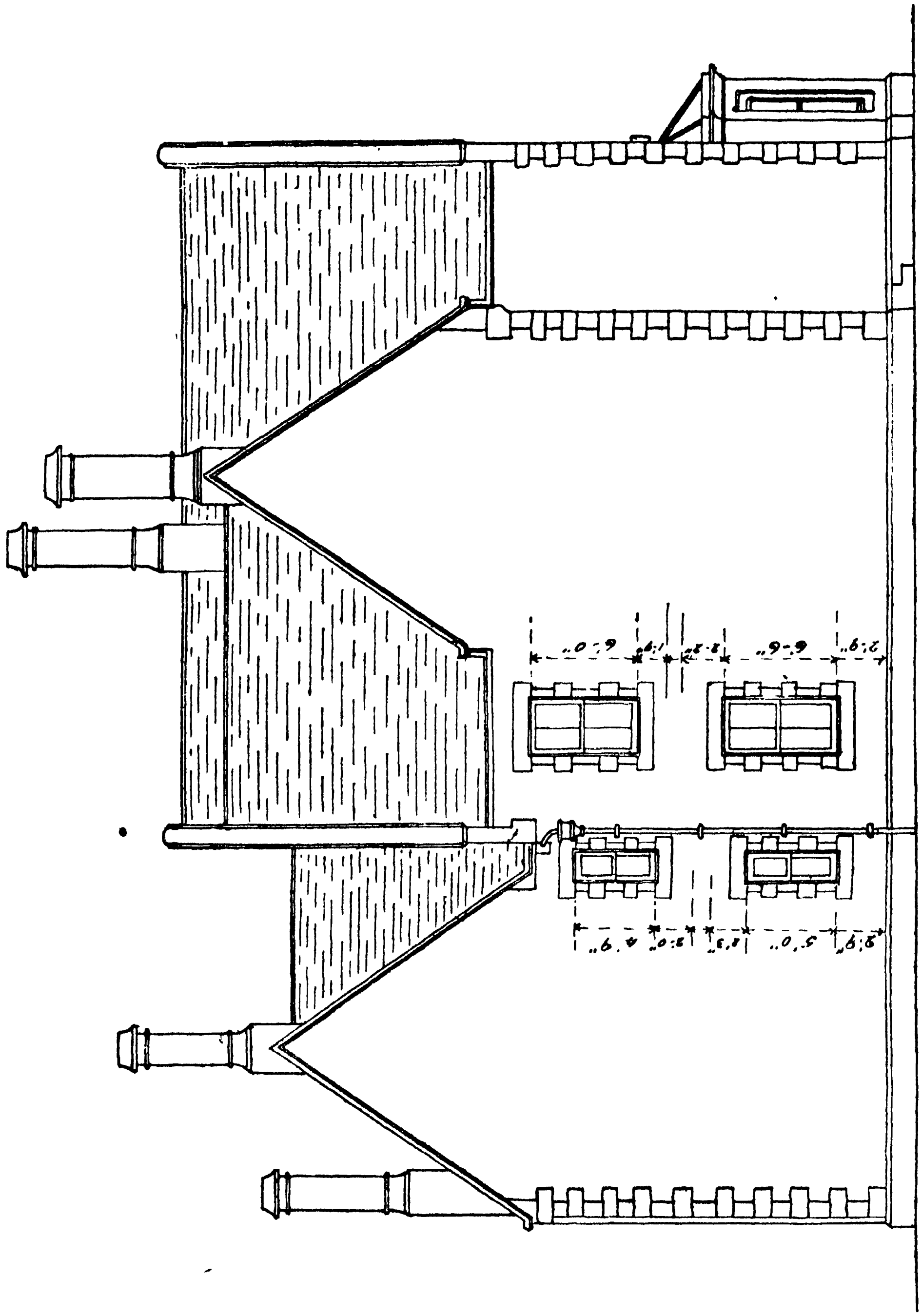


FIG. 7.—SIDE ELEVATION.

THE YOUNG ARCHITECT.—*WORKING DRAWINGS* (*see Text*).

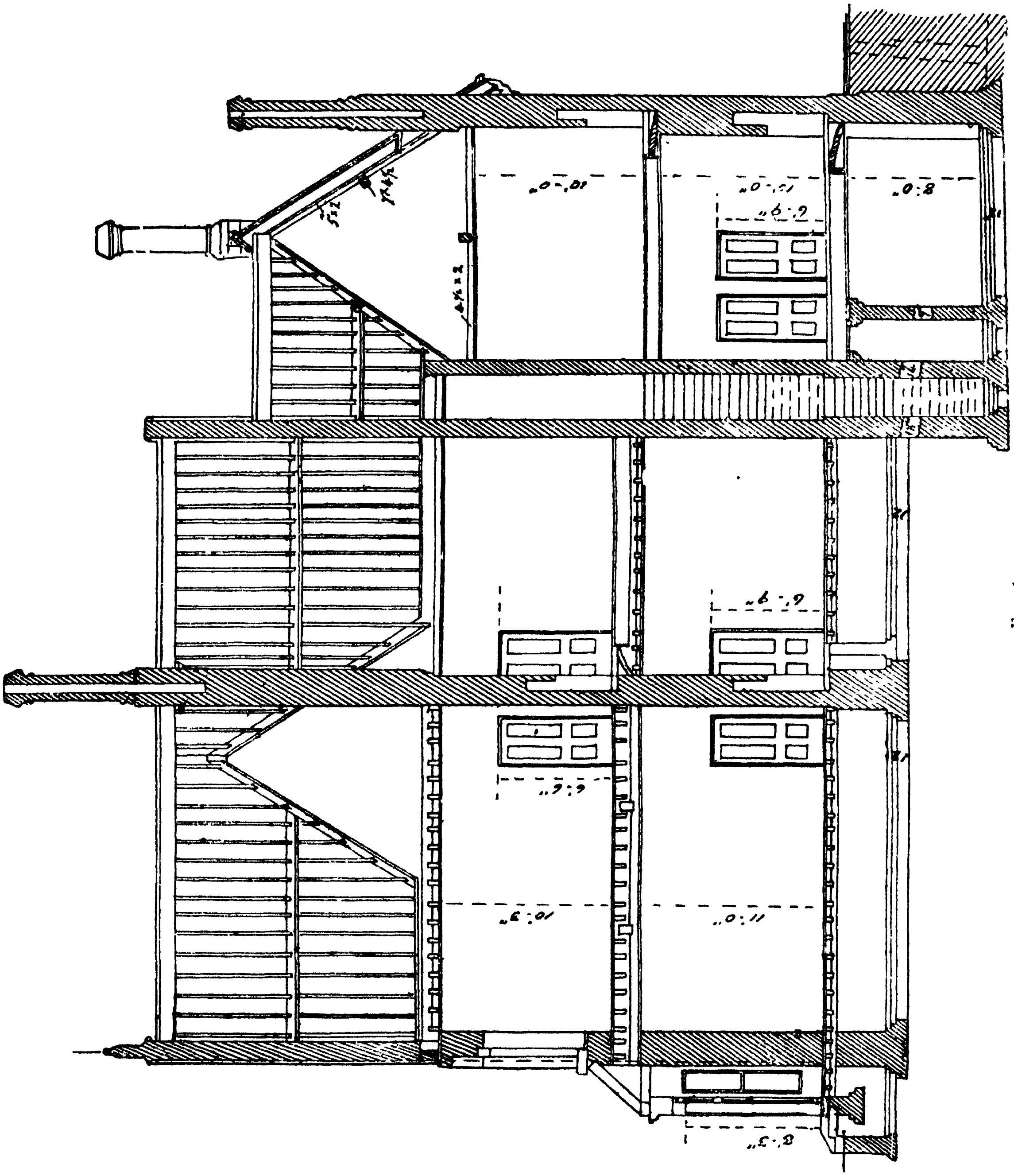


FIG. 10.

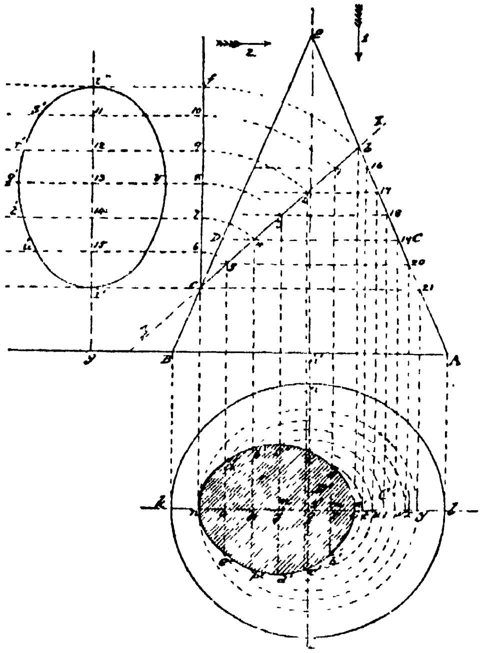


FIG 1.

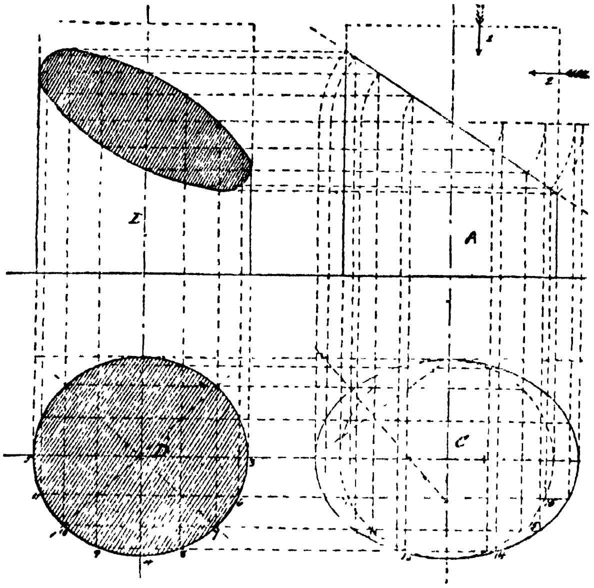


FIG 2.

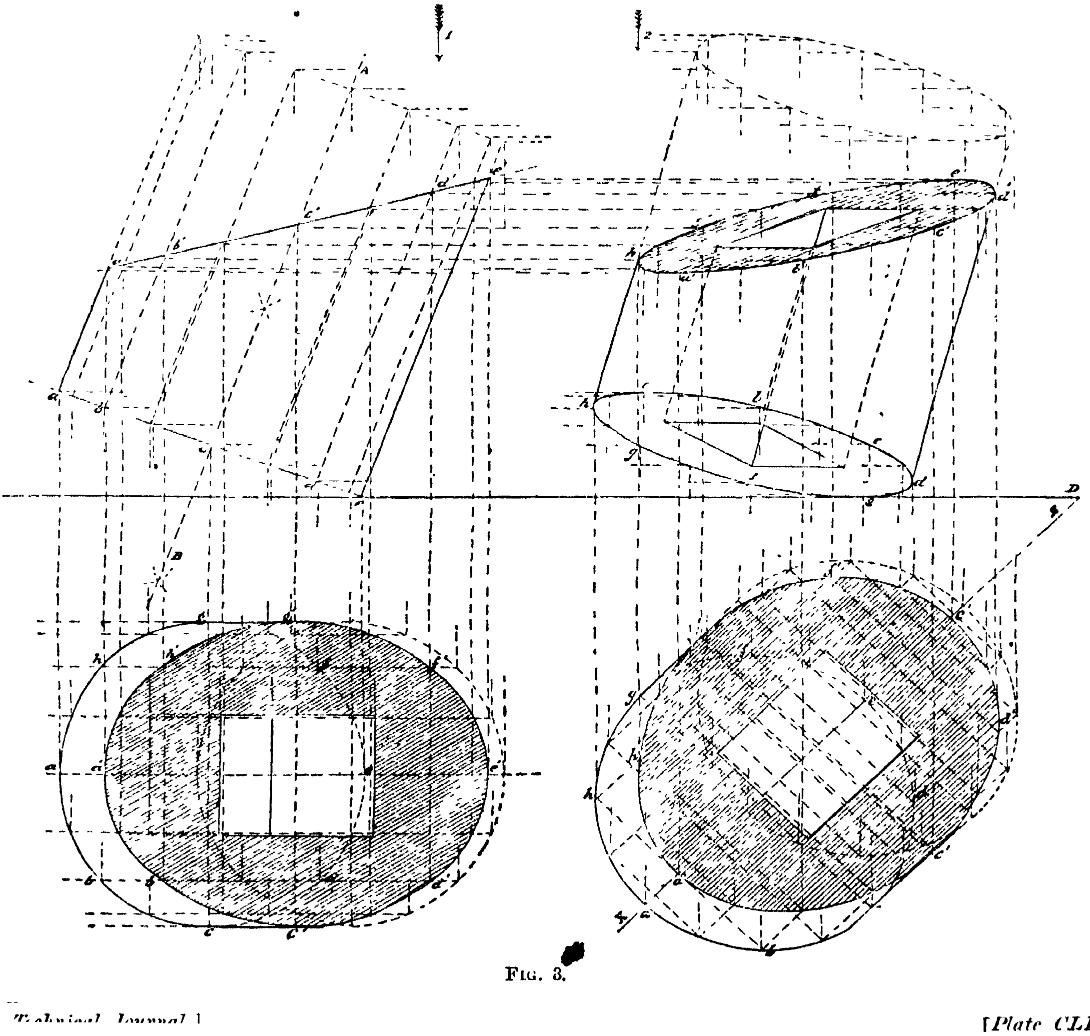


FIG. 3.

THE BUILDING AND THE MACHINE DRAUGHTSMAN.

CHAPTER XIII.

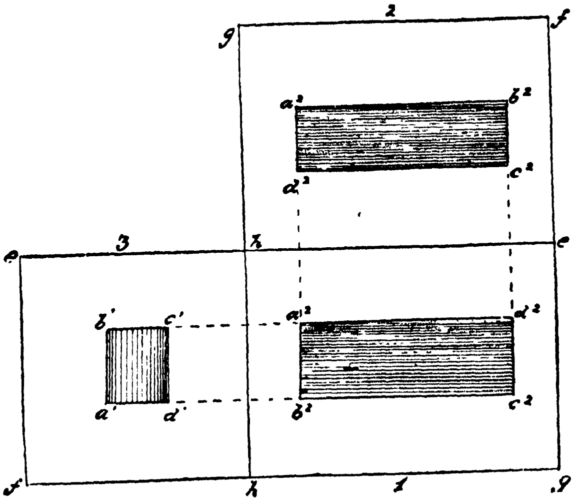


Fig. 25.

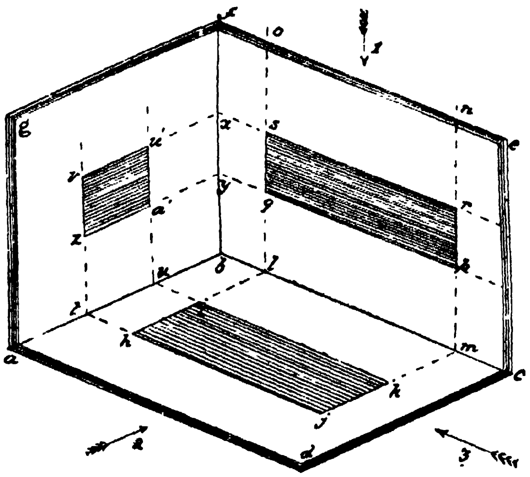


Fig. 26.

At the conclusion of our last chapter we pointed out the way in which the planes of projection were connected, but so that they could be all shown on one flat surface. In like manner the separate projections in figs. 19, 22 and 23 are shown in fig. 25 spread out on one surface or plane, which lies on the surface of the sheet of paper on which the diagram is drawn; the three planes of projection on which the different views or parts of the solid block or box are drawn or projected being all placed in due relation to one another, when it is desired to show the three views together on one piece of paper or plane surface. Those three views shown separately in figs. 19, 22 and 23 are, as we have seen, first the "plan of top" of block, or of bottom as the case may be, both being equal in dimensions, this being given in fig. 19; second, the "elevation of side," in fig. 22; and third, the "elevation of end," in fig. 23. In fig. 25 the relation of the three planes of projection of those three views of the same object is shown: thus, the surface *h g e h* is the plane of projection of "plan of top," corresponding to *e f g h* in fig. 19; the plane surface *e f g h* in fig. 25, the "side elevation" corresponds to the [illegible]

[illegible] projec- [illegible] ven in fig. 25, is obtained with the three planes as placed in the relation shown, will be seen by the inspection of fig. 26, which represents the three planes in figs. 19, 22, and 23, drawn in the same style of graphic illustration, which we may here note is a species of perspective, or conventional mode of representing an object pictorially which we have devised for the purposes of our illustration. This species of conventional perspective has some relation to the variety of perspective known as "isometrical," which, possessing many features of practical value to the draughtsman, will be duly explained further on. In fig. 26 the plane of projection *a b c d* corresponds to the plane of projection *e f g h* in fig. 19, on which the "plan of top" of solid block or box is projected. The plane of projection *e f b c*, fig. 26, corresponds to the plane *e f g h*, in fig. 22, and in which the "side elevation" of block is projected. The plane of projection *a b f g*, fig. 26, corresponds to the plane *e f g h*, fig. 23, in which the elevation of end of block is projected. In this diagram, fig. 26, the two planes *b c e f* and *a b f g* stand vertically or at right angles to the plane *a b c d*, which is horizontal. And, as we have said, it is upon all vertical planes that "elevation," and in all horizontal planes that all "plans" are projected, or supposed to be projected. Now, if while standing vertically, as in the diagram, the planes *b c e f*, *a b f g*, fig. 26, were pressed outwards and downwards, turning respectively on the lines *a b*, *b c*, as hinges, and the pressure continued till they lay flat or pressed upon the surface of drawing board, they would obviously be flat, like the plane *a b c d*; and the three [illegible]

as in fig. 25, which is the "spread-out" [illegible] fig. 25. To thoroughly understand this principle here illustrated, which carries with it much that is of essential importance in the practice of drawing, we would counsel the youthful draughtsman to project different views of an object, as in fig. 26, and then press down or "spread out" the planes as in fig. 25.

Some Practical Points connected with Projection on Plane Surfaces.

We use the term "supposed" in the above paragraph with a practical purpose in view, which will be further made clear presently; suffice it now to say that there would be obvious inconveniences in showing or displaying the various views of a given object in planes of projection placed in relation to each other as in fig. 26. For the draughtsman has only a plane or flat surface—that of his sheet of paper—to draw upon; and although it is quite true that he could "project" his different views of an object in three planes, as in fig. 26, and that they would still be on a flat surface—a sheet of paper, just as diagram fig. 26 is on the flat surface of the page—nevertheless it will be seen that the plane of projection, of which the principle is shown in fig. 25, possesses practical advantages over that shown in fig. 26. But this diagram in fig. 26, and those preceding in figs. 16 to 24 inclusive, and their respective descriptions, are essential to the due understanding of the principle on which the practice of plane projection, known as architectural and engineering, or more popularly mechanical drawing, is founded or based, and of which the numerous examples given under different sections in succeeding chapters in the present series of papers will give ample illustration.

But the purpose for which fig. 26 has been designed is not yet exhausted. It serves to explain another principle of practical projection or drawing —namely, how after the projection of one view is completed, the lines which give data or points useful in the projection or drawing of another view of the same object can be obtained directly. This principle, by which in the practice of projection much time is saved in finding—that is, measuring and setting off—the distances which give dimensions of the different views of a given object, is so important that it will be fully illustrated in a succeeding chapter, when we come to the consideration of working drawings. But it may be indicated here in connection with fig. 26, and at the same time the general principles of projection already so far illustrated and explained will be made more clear and explicit.

Let us suppose, then, that the "plan of the top" of the solid block, already so frequently referred to, and the projection of which is given in fig. 19, is in the first place projected; and so as to occupy the central space of the horizontal plane of projection $a\ b\ c\ d$, fig. 26. The projection thus obtained will be at $h\ i\ j\ k$. We have said above that one view being drawn, it will give data or points by which the drawing of another view will be facilitated, and this by saving the time necessary to find points or to lay down or set off dimensions required for this other view. This principle is explained in fig. 26. Thus continue or extend the lines $h\ i$, $j\ k$, till they cut or touch the "base line" or "ground line" $b\ c$ of the vertical plane of projection $b\ c\ e\ f$ in the points l and m. From l and m draw vertical lines—parallel to $c\ c$ or $b\ f$—extending indefinitely as in the direction $m\ n$, $l\ o$. The distance between l and m or between n and o will obviously be equal to the distance $h\ j$ or $i\ k$—which corresponds to the "length" of the block or box. At any convenient point, as p, on the vertical line $m\ n$, draw parallel to $b\ c$ the line $p\ q$. Next take the distance or dimension of the "height" of the block, as $a\ d$, or $a^2\ d^2$, from fig. 23, and set it off from the point p, fig. 26, to the point r on the line $m\ n$. Then from point r draw parallel to $p\ q$ or $b\ c$ the line $r\ s$, cutting line $l\ o$ in point s. We have thus the outline of the "elevation of the side" of block corresponding to the projection $a^2\ b^2\ c^2\ d^2$ in fig. 22. Here in obtaining this projection $p\ q\ s\ r$ in fig. 26, we have obtained in the most direct way some of the points giving dimensions of the side elevation from the plan $h\ i\ j\ k$. And this will be more quickly done in practice than it takes here to describe it. But the principle here involved receives another illustration, and a more complete one; for having thus obtained the two views of the block—the "plan" on the plane of projection horizontal, $a\ b\ c\ d$, and the "side elevation" on plane of projection vertical, $b\ c\ e\ f$—we can from these find data or points by which without further measurements we may obtain the projection of the "end elevation," corresponding to the projection of it in fig. 23, at $a'\ b'\ c'\ d'$. How this is done will be explained by inspecting fig. 26. Continue the sides $j\ h$, $k\ i$, of "plan" till they cut the base line $a\ b$ of the vertical plane of projection $a\ b\ f\ g$ in the points t and u; and from these points draw vertical lines parallel to $a\ g$ or $b\ f$. Next continue or extend the sides $p\ q$, $r\ s$ of "side elevation" till they cut the line $b\ f$ in the points x and y; and from these points draw, parallel to $a\ b$ or $f\ g$, lines cutting or intersecting the lines $t\ v$, $u\ w$, in the points v, w, a', z. The rectangle $v\ w\ a'\ z$ is the projection of the "end elevation" of the block corresponding to $a'\ b'\ c'\ d'$ in fig. 23. This principle of finding from one projection or view of an object data or points giving dimensions of another projection of the same object, is also illustrated in the "spread-out" of fig. 26 which is given in fig. 25. The dotted lines in this last-named figure will show how the points are obtained. The principle here illustrated will be further made clear in a succeeding chapter in its application to the preparation of working drawings.

In proceeding to explain the application of those general principles to the special departments of the work of the architectural and engineering draughtsman, let us briefly recapitulate, by way of introduction to this, the leading features of projection. In figs. 25 and 26 we illustrated and explained the meaning of the terms "plan" and "elevation," and how these were related to each other in the "planes of projection." The rays, if we may use the term, coming from or cast by the points of the objects being supposed to proceed from or to be looked at from a point of infinite distance, and thus being "projected," so to say, from the point's object to the eye of the spectator, those rays are projected in parallel lines at right angles to the two planes of projection—the vertical and horizontal. We shall now proceed to show how, by the use of these parallel lines, the various views of objects required in architectural and engineering drawing may be obtained; the plane of projection being supposed to exist upon the sheet of paper upon which the draughtsman has to prepare his drawings. By this supposition the operations are much simplified, although it is always necessary to bear in mind the principles illustrated in the various diagrams we have given—in figs. 16 to 26 inclusive.

In those diagrams we have reached the point at which we could explain the terms "plan" and "elevation," and how they stood—so to say -in relation to each other; this relation affording certain data or points useful in facilitating the projection of different views or projections of the same object. But both plan and elevation are concerned only with the exterior or external surface of solid bodies. We used the term "solid" in its direct or special acceptation only—that is, as a body having three dimensions, length, breadth or width, and thickness or depth—thus distinguishing it from a surface or superficies, which has only two dimensions, as length and breadth or width. But although we use the term solid body or object of any particular shape or form, this is only to be taken relatively or with a reservation and in the sense above stated, as connected with its exterior as possessing length, breadth, and depth. For although in this sense a body is solid, or termed such, it may not be absolutely solid, in the sense that a block of wood or of other material is solid, its interior being made up of a conglomeration of the same particles as the outer surfaces are composed of. But a solid body, in the reserved sense we have illustrated, may, while possessing externally all the characteristics of a solid, be hollow or partially hollow in the interior. Thus a hollow "shell," considered only in relation to its exterior surface, is considered to be and is termed a solid sphere or globe; yet internally it has a "void" space—this being determined in point of cubical space or contents by the thickness of the metal between the exterior surface and the interior void or hollow space. We can conceive of the block of wood, of which "projections" are given in figs. 19, 22, 23, 25 and 26, to be in like manner hollow or partially hollow—that is, with void and solid spaces alternated according to a certain design and to serve a certain purpose or purposes. But it is obvious that, so far as the exterior surface of the block gives any indication, we have no means of knowing what its interior condition is. But in practical construction it is necessary to give drawings from which to work, which explain the peculiarities of a body that has its interior fashioned or hollowed out in a certain way. In many cases in engineering drawing the whole value or peculiarity of an object lies in its interior arrangements, the outer surface being in point of fact only a covering for the internal work or arrangements. Some method, therefore, of showing in projections or drawings what the character or nature of the interior of a solid body is, is clearly required.

This necessity of practical projection is met by what is called a "section," or by "sections." The term is derived from the Latin verb *seco*, I cut; and it gives at once the true meaning of the term "section." This is simply a cutting through of a solid body—solid in the conventional or reserved sense, as already explained—in such a way or in such a direction as will suffice to show by the character of the two portions thus obtained, termed technically "sections," what the construction and arrangement internally is. Thus, in fig. 27 we give at *a b c d e f g* a diagram in which the three projections in figs. 19, 22, and 23 are combined in one; thus, *a b c d* is the projection of $a^2 b^2 c^2 d^2$ in fig. 19; *b c f e* the projection of $a^2 b^2 c^2 d^2$ in fig. 22; and *a b e g* the projection of $a' b' c' d'$ in fig. 23. The whole of these combined, as in the diagram, give the projection of the block or box previously referred to, in a species of perspective view.

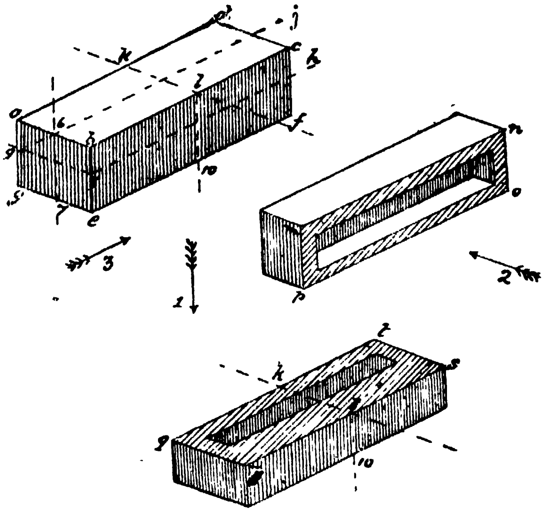


Fig. 27.

If the object they represented in *a b c d e f g*, fig. 27, were a solid block, it is obvious that if sawn or cut up by lines parallel to either the top, as 9 *h*, the side, as 6 *j*, the end, as *k l*, or even by a line or lines oblique to these, as in the direction of *b d*, all the cuttings or sections would still show on their faces the appearance of solid surfaces. The external projections being given would be all that was required, as these would give at once the form and dimensions. But if diagram in fig. 27 at *a b c d e f g* were not the projection of a solid block, but of one which, while it had externally the characteristics of this solidity, possessed also internal peculiarities, hollows, or vacuities, it is obvious that the projections of the external parts, as of top, side and end, would give no clue to what were the peculiarities of the interior. And just as the curiosity of a boy prompts him to break up his toy to see " what is inside of it," so before we could know what were the internal peculiarities of the block or object in fig. 27, we should require to break or cut it up, or to open it up.

But as the designer of the object knows, of course, from the beginning what are the peculiarities of the interior, he so arranges his " set of working drawings " of it, that certain " projections " or drawings will show those peculiarities. So that if we possessed those we should know how the inside of the block was arranged and constructed, just as well as—in some senses better than—if we had broken or opened it up. Those projections extra to those showing the external characteristics are, as we have seen, termed sections.

Still keeping to the illustration in fig. 27, at *a b c d e f g h*, let us, by examining it, endeavour to convey to the student of projection or drawing as applied to the work of the architect or the engineer, a knowledge of the principle upon which " projections of sections " are made, and what the different kinds or classes of sections are. Let us suppose the object—a block, or solid body, shown at *a b c d e f g*—to be sawn or divided into two parts in the direction of its length and at the dotted line 6 *j*. The division or sawing in two being completed, let us remove and put aside the half represented by the part *b c f e*, leaving the other half, as *a k d*, to remain in position. Looking at it as it thus stands, we see at once what its peculiarities are, these being shown in certain lines on its face. If a projection of this face were made, we might suppose that the lines would be as in the diagram *m n o p*, in fig. 27. On examining this we see at once that the inside of the block is provided with a vacant or hollow space of a rectangular form and of a certain depth. If this vacuity extended right across the width of the body, it is obvious that in this case the projections of both of the sides of which one is seen at *b c f e* would have shown in the centre a rectangular vacant space precisely as shown in the diagram *m n o p*. But the space does not go through and through the block, but is terminated at a point a certain distance within the sides, and the depth of the vacuity is shown in diagram *m n o p*. The projection here shown is, in the technical language of the draughtsman, said to be, and is talked of as, a " section on the line 6 *j* "—and as the cutting or sectional line is in the direction of the " length " of the block or object, it is further said to be a " longitudinal section on the line 6 *j*." The projection being taken on a vertical plane (see figs. 16, 17, 22, 23), and as all projections on " vertical " planes are elevations, the section here shown may also be called a sectional elevation or a section in elevation. But as a mere inspection of the drawing of an object shows whether the projection is on a vertical or horizontal plane, this term elevation is supposed or included in the title generally employed and given above as a " longitudinal section on the line *i j*." But another term is sometimes introduced in giving the title to a section of this class. It will be perceived that the cutting line 6 *j*, while it extends along the whole length of the block, extends also the whole depth, as from point 6 to 7. This line being in a " vertical " direction, the term is by some draughtsmen included in the title of the section, with whom, therefore, it would read as a " vertical longitudinal section on the line *i j* "; or partly transposed thus—a " longitudinal vertical section on the line *i j*."

Longitudinal sections may be required, however, in other directions. Thus, suppose, as before, that the block *a b c d e f g*, fig. 27, is cut into two parts—but in place of the cutting line being in the direction of *j* 6 7, it is taken in the direction of *h g*, and across the width or breadth of the block from 8 to 9. If the upper half, as *a b c d*, be removed, leaving the lower, as *e f*, in position, or *in situ*, as the technical phrase is, we may suppose that the exposed face of this lower half would be as shown in the diagram *q r s t*, with a hollow or vacuity, as at *u*, this being placed nearer to one side of the block than to the other, giving unequal thickness at the side, as shown in the projection or drawing. This projection is a section, and it is again described or titled by the draughtsman as a " section on the line *g h*." But as all projections taken on " horizontal planes " (see figs. 19 and 20) are plans, such a section is often termed a " sectional plan on the line *g h*," or as the line 8 9 is horizontal, it may further be, and in practice often is, entitled a " horizontal section on the line *g h*." The interior of an object may be so varied in its arrangement that several sections, both vertical and horizontal, may be required. We can, for example, suppose the block *a b c d e f g*, in fig. 27, to be made up of a series of parts horizontally superimposed upon each other, making up the height or depth as *c f* ; and each of these horizontal parts having its own peculiarity of internal arrangement.

THE GRAZIER AND CATTLE BREEDER AND FEEDER.

THE TECHNICAL POINTS CONNECTED WITH THE VARIETIES OR BREEDS OF CATTLE—THEIR BREEDING, REARING, FEEDING, AND GENERAL MANAGEMENT FOR THE PRODUCTION OF BUTCHERS' MEAT AND OF DAIRY PRODUCE.

CHAPTER XIII.

Some Points connected with Fat Cattle fed Exclusively for the Butcher (*continued*).

AT the conclusion of our last chapter we stated that everything about the shorthorn showed that he was essentially a butcher's beast. His build or frame, large and massive, yet carried by bones light in proportion to his weight, gives that breadth and fulness so favourable to the carrying the maximum weight of flesh, and those at parts the most favourable for the deposit of that which constitutes what are called the "best cuts" of the juiciest and most nutritious flesh. The deep and square quarter, of great length also, gives, with the full and fleshy limb, the fine heavy "round," the valued "rump," and the useful "hough," out of which the butcher makes his profits. So also in the level, square and broad hips we find the locality of and the best form for a fine and heavy loin. And so all round we find excellences at almost every point; the full arched and rounded barrel gives the fine ribs, which are alike valued by the customers of the butcher, and are one of the best indications of the best fattening beast. The animal which is the poorest for the purposes of the butcher possesses characteristics quite the opposite of the above, and more or less defined in proportion to its condition. In this we find the short and shallow quarter, with its light, more or less fleshless limb; the flat rib giving the rectangular barrel--if that term can be applied to a part which does not possess the fine, full, arched ribs of the shorthorn. In the poor butcher's beast we have also the narrow chest, and, in brief, the points which give the results the very opposite of the desiderata required by the butcher, and aimed at by the breeder—namely, a small proportion of live weight to the beef or carcase weight; and deficiency at the very points where the best quality of beef can be laid on. But, however good the breed may be, there are certain points which materially modify the practical results of breeding and feeding so far as the butcher is concerned. To some of these we now draw brief attention.

First, that involved in the phrase "a fat ox," "bullock" or "steer," the expression "a fat cow," as a butcher's beast, being never, or but rarely, used. This clearly indicates that sex is one of the points which concern the grazier in producing meat for the butcher. A brief consideration of the points offered by the bull and the cow of the same breed will show clearly that the male animal is the one best fitted for laying on flesh suited for the butcher. Of the two, breadth, massiveness and weight, and general fulness, characterise the male animal as compared with the female. The internal capacity of the bull is less than that of the cow, the space being greatest in the cow which has had calves; so that in the bull there is a higher proportion of meat or flesh, or "carcase weight," to the dead or live weight, than in the cow. In the bull we have a thick massive neck, in the cow a thin one. And, taken as a whole, the bull gives a denser, more solid flesh or meat, or, as it is popularly termed, beef, and this through the general absence of fat interposed between the layers of the meat; the meat of the cow, on the other hand, is not so dense, as it is often intermixed with fat. A barren cow or heifer (pronounced heff-err) and a bullock or steer, which is an emasculated bull, occupy in their physical or bodily characteristics a medium point between those of the bull and the fertile cow, they however changing their disposition, so to say—that is, the cow has a tendency to become masculine in characteristics, the bullock, or steer—as it is otherwise and often called- on the contrary, having a tendency to become feminine in external characteristics. Both, however, maintain the relative position as regards sex which distinguishes the bull from the fertile cow, as above stated—that is, the male animal, the bullock or steer, possessing a larger proportion of flesh or beef to the carcase or live weight than the barren heifer.

Whatever the sex and the class of cattle, the proportion between its weight of flesh, or butcher meat,—or carcase weight, to the live weight of the animal as it stands, is more or less, but always, influenced by the physical state or bodily condition in which the animal is. The terms "good" and "bad condition" as applied to cattle designed for the butcher are familiar to every one; and what they generally imply is no less so, although it is only the expert who can tell the particular points by which condition is decided. But although the nicest points are known only to the experienced, it is within the comprehension of every one who chooses to observe at all how changes in the mere physical conformation of an animal are brought about by the process of fattening or feeding on the one hand, or of low living, approaching more or less nearly to the starvation point, or that in which but little more than existence is secured, on the other. In the process of feeding and "fattening up" a beast which has been thus "let down" through bad or defective feeding and treatment, the changes may not be traceable from one point to another of short periods of time, or at particular points of the animal; but after a certain period of good feeding and treatment the general change cannot fail to be noticed—all the more observable if the animal has not been seen at all from the period when the good treatment was commenced. Hollows will have been filled up, protuberances will have disappeared, a sleekness and fineness of the coat of the animal, a mellowness of touch, will be present, and a general roundness and fulness of the whole frame will have taken the place of the hollow sides and flanks, the protruding bones, the rough staring coat, and the harsh touch of the hide. The very gait and look of the animal will be seen to be quite different to the listless and what may be called hopeless movements, and the dull watery eye of the animal when in its half or nearly wholly starved condition. On the supposition that the animal is full grown, the change which has taken place in its general appearance cannot have lain in any increase in size of the frame or bones—those of necessity remaining the same as before: the change must have taken place in other directions. And those are external and internal. Of these, the first is that which is alone obvious to the spectator; the second only so after the animal is killed and cut up. The external change consists in layers of flesh, or, as we popularly term it, meat, formed on the bones or the frame between it and inside of the hide or skin. The value of this will vary according to circumstances, some of which have been already, others will yet be described; but it is quite evident that, as compared with the animal in its previous ill-fed condition, the weight of its meat or flesh must have increased: the thicker the layer of flesh laid on the frame, the heavier the weight; and of this flesh some parts will be more valuable than other parts, according as they are at the parts of the body which give what are called the "finest cuts of butcher's meat." Hence, as we have seen, the importance of the choosing of a breed which gives the greatest increase of flesh at those parts giving the finest cuts, at the lowest expenditure of feeding changes.

Turning now to the internal changes in the animal, consequent on the good feeding and treatment named in the preceding paragraph, we find that these consist chiefly in an accumulation of fat around the kidneys, and within or lining the inner side of the ribs—this last being very considerable in very obese or fat cattle—and this adds to the carcase or meat weight of the animal. A secondary increase arises from the accumulation of fat around the stomach and the entrails, which fat is technically termed the "caul." We name this as a secondary addition to the substance of the animal; for while it of necessity adds to the live weight of the animal, it does not add to the carcase or meat weight, inasmuch as it forms part of what graziers and butchers call the "offal." Technically a fat beast for the butcher is considered as being made up, first, of the flesh or meat or carcase weight, which includes only the selling meat—lean and fat; and second, of the offal, which includes the hide or skin, the tallow or the loose fat, the caul—surrounding the stomach and entrails—and the blood. The proportion which the carcase or selling meat weight bears to the dead weight of the animal varies according to circumstances, but chiefly to its condition; various experiments have been made to define, if possible, by some "constant" the value of this proportion, and 60 per cent. has been state as the result of these. But, as just said, the circumstances are so varied that it is impossible to give a constant proportion for weight of meat or carcase to dead weight; roughly it may be taken as between 50 and 70 per cent. With the increase of internal fat now described as taking place in an animal well fed and cared for, comes a decrease of the size of the digestive organs. This must be so, for, as the frame of the animal admits of no change, and as this defines the internal space or cavity for the digestive and respiratory organs, as the fat increases the digestive organs decrease in size. And with this decrease comes a decrease of appetite of the animal. This result almost every one knows who has had anything to do with or observed much of fattening cattle; for the fatter they become the less eager is their appetite and the more fastidious their taste, food being rejected which in an earlier stage of their fattening would have been taken and devoured eagerly. We have said that the external change in the condition of a fattening beast consists in the addition of flesh or meat, which technically is known as "lean" o "lyer." But to the increase of this lean beef or meat a limit is placed, it not increasing beyond a certain point, which point varies with varying circumstances. After this limit is reached the increase of size or thickness of external covering of the frame is made up of fat. Fat, it is scarcely necessary to say, considered as an animal substance, adds nothing to the strength or muscular power of the beast; this comes alone from the lean, which is the substance of the muscles, those giving strength and vigour to the animal. In the case of animals at one time fat, but which are neglected and half starved, the fat goes to maintain the animal and supplement the food supplied in too meagre a quantity to keep up the condition of the animal. The fat being thus absorbed into the system, soon disappears, and the animal is "lean and hungry" as before. The process of fattening a beast for the butcher—which fattening is scarcely an accurate expression, though almost universally used, inasmuch as it at least conveys to the popular mind that fat was the only substance aimed at—consists internally in the formation both of fat and of lean, and is only carried out in the case of fully matured animals. Up to and below this condition, so much of the food goes or seems to go to the strengthening of bone and the formation of the frame.

THE CALICO PRINTER.

THE CHEMISTRY AND TECHNICAL OPERATIONS OF HIS TRADE.

CHAPTER XI.

SIMPLE though this process may appear, it presents ample scope for the exercise of the skill of the experienced dyer. The strength and temperature of the dye-bath, the time the cloth remains in contact with the dye liquor, and the speed at which the cloth should be kept moving, are all conditions requiring proper adjustment. There should, as a rule, be present in the dye-beck a quantity of dye but slightly more than is necessary to saturate all the mordant, as, if a large excess be present, the whites are apt to become permanently tinged with the colour, and also irregular dyeing is apt to ensue. The temperature and time adopted in dyeing should be those which previous experiment has shown to be best adapted to dye up the particular colour. A few examples will illustrate these points. For dyeing up a deep alizarine scarlet upon cotton, upon the mordant given below, 10 to 14 oz of alizarine extract at 10 per cent., according to the pattern, is required for every piece of 25 yards of cloth. The cloth is dyed from one to one and a half hour at a temperature of from 100° to 170° Fah.

Mordant for Red.

Acetate of Alumina, at 12° Tw.	3 gallons
Flour	6 lb.
Water	1 gallon
Tin crystals	4 oz.

This mordant is printed on unprepared calico, aged, dunged, dyed up as above described, prepared in oleine oil (1 part oleine to 16 parts warm water), dried, steamed two hours at 5 lb. pressure, and soaped; the first soap beck at 165° Fah., the second and third at 180° Fah., and then well washed in clean water and finished. When aniline black is printed along with dyed-red, the black colour and the mordant for red are printed on in a two-colour printing machine, aged in steaming machine for three minutes, at 4 or 5 lb. pressure, at 180° Fah., dunged, and dyed, etc., just as above described for red alone. A heavy pattern—that is, a pattern printed with a deeply-engraved roller—requires more alizarine for dyeing it up than a lighter pattern, simply because in the former case more mordant is printed on the cloth than in the latter.

The Machinery of the Dye-house.

This is comparatively simple: the dye-beck, which is of the same construction, with but slight differences of detail, whether used for dyeing or soaping or dunging, etc., consists of a wooden trough or box about 8 feet long, 5 feet wide, and 5 feet deep, divided into five compartments by four divisions made of wooden framework. This trough or beck is surrounded by a wince or reel about 3 feet in diameter, which carries or supports the cloth in its motion during dyeing; on its circumference are seven or eight bars for the purpose of giving the cloth a better hold; it revolves upon an axis on each end which moves in a pivot, and worked by a strap or rope driven by power. The beck can be covered in at pleasure by means of four hinged lids; the two at the top open upwards, the two side lids open downwards. The cloth, as it leaves the beck, passes between two rollers, and receives a gentle pressure.

The water of the dye-beck is heated by steam, which enters by the perforated pipe which projects into the back. The supply of steam is regulated by a screw-valve. The water enters by a stopcock. In working the machine three pieces of cloth are introduced into each compartment, or fifteen pieces to one beck; each triple is passed over the wince, and the six ends tied together respectively, making five endless webs in the beck. The wince being now set in motion, the goods are drawn up from the one side of the beck, over the wince, and down into the corresponding compartments on the other side. The pieces, in passing over the wince, are prevented from entangling in the ascent and descent by projecting bars.

Another form of dyeing-machine, similar in principle to the washing machine drawn in fig. 2, Chapter I., consists of an oblong wooden trough, divided lengthways into two equal parts by a perforated wooden wall, surmounted by two wooden rollers, the lower one being large, the upper one smaller. The cloth enters the machine between these rollers at one end, and falls into the water trough beneath, and continues to fall in until several yards have accumulated; it then ascends between the two rollers and falls over the other side; descends again into the trough, into the other back division, passes underneath the perforated division, and ascends again; and so continues repeatedly ascending and descending until it passes out of the machine. The machine may, of course, be speeded so that the cloth takes any desired time to pass through. Usually the lower (large) roller only revolves, and the weight of the upper one is sufficient to "nip" the cloth through. It is almost needless to add that the details of the construction of so simple a machine as that we have described vary considerably in different works. This machine generally holds from seven to fourteen pieces of cloth of twenty-five yards each.

Indigo Dyeing.

Indigo dyeing, though in principle different to that of alizarine dyeing, finds a fit place for treatment in the present chapter. Indigo, as met with in commerce, is a dark-blue solid, insoluble in water; but when it is subjected to the action of "reducing agents,' it loses its blue colour, turning pale-yellow, and becomes soluble in water. When cloth is immersed in this "white indigo," as it is termed, it enters the fibres of the cloth, and on exposure to the air, oxidation takes place, and the white indigo is converted back into its original condition of dark-blue indigo, and being now insoluble, it cannot be washed out, and thus the fabric is dyed. This is the principle of indigo dyeing. The indigo first requires to be subjected to the operation of grinding. The hard lumps of indigo are first allowed to steep for fourteen days in water, and the indigo and water are then put into the grinding mill, and ground up until reduced to a smooth paste. This takes from sixty to one hundred hours grinding, according to the power and construction of the mill. A small quantity of caustic soda solution is added to the contents of the grinding mill; 1 "gill" (that is, half a pint), at 70° F., to every 60 or 70 lb. of indigo. This addition acts in facilitating the grinding operation. It is now ready for the vat. There are several ways of reducing the indigo in the vat, but the following two methods are the best.

1. *The copperas and lime vat.*—This vat is simply a deep oblong box, made of slabs of stone or of wood, and of any convenient size, with a series of rollers both at the top and bottom, to carry the cloth through, and surmounted by a wince or reel. The cloth is drawn through the vat by the gentle "nip" or pressure of the two wooden rollers, between which the cloth passes when leaving the vat, and then the cloth passes over the wince, and is received in barrows. Three parts of freshly slacked lime are made into a cream with a little water, and put into the vat. One part of the paste of indigo is then added, and the whole thoroughly mixed. Three parts of good sulphate of iron or copperas, dissolved in a little hot water, are then gradually poured in, the whole being well stirred all the time. The mixture is then left standing for several hours, during which the contents are occasionally stirred. The mixture will then have assumed an olive-yellow colour, showing the reduction to be complete. The requisite quantity of water is then slowly added, with gentle stirring, and the goods are run through. The strength the vat is made—*i.e.*, the quantity of the above mixture of lime, copperas, and indigo added—does not depend upon the shade of indigo to be produced, nor upon the quality of the cloth to be dyed; as when a deep shade is desired the goods are run through the vat twice or oftener, until the desired shade is reached. In this way a more uniform shade is produced than when the goods are run through a stronger vat, or are longer in contact with the liquid. The cloth as it leaves the vat is of an olive-yellow or greenish hue, but quickly becomes green, and then blue, as the air oxidises the colour. As the vat becomes exhausted it must be "freshened up" by the addition of reduced indigo. By varying the number of times the cloth is dyed, and the time of passage through the vat, different shades of blue, varying from pale blue to deep indigo, may be obtained.

2. *The zinc powder vat.*—This is a more recently discovered vat, and is now largely employed. The reducing agent is finely powdered zinc in place of lime and copperas. The following is the mode of proceeding. As much indigo paste as is worth £12 is placed in a tub, and filled up to 80 gallons with water, and 24 lb. of zinc preparation is added, and the whole well stirred. This is allowed to stand several hours, and is put in the vat, which is diluted with water, and is ready for dyeing. This method of reduction of the indigo possesses several advantages over the copperas method. It is not so liable to froth, which is a troublesome property of the old vat. It is, moreover, cleaner, as it does not leave so much residue or "bottoms" in the vat, and is more regular in working.

The Chemistry of Acids, Alkalies, Salts, Mordants, and other Drugs used by the Calico Printer.

ACIDS.

Hydrochloric or Muriatic Acid, or Spirit of Salt (HCl_1). Used in bleaching and in making muriates or chlorides. This is a strongly-acid, fuming, volatile liquid; colourless when pure, but usually more or less yellow from the presence of iron and organic impurities. Iron, except in small quantities, may be highly injurious. It also generally contains sulphates, and arsenic, which, as a rule, are not injurious, but, when present in large quantities, cause the acid to appear stronger than it is in reality by raising the specific gravity of the liquid. As met with in commerce, it stands at from 27° to 32° T., and contains from 27 to 35 per cent. pure acid (HCl).

Ordinary hydrochloric acid consists of a solution of gaseous hydrochloric acid, HCl, in water; in which it is very soluble: one volume of water at 0° C. absorbs 503 volumes of the gas. On heating, a concentrated aqueous solution of the gas comes off, and the solution becomes weaker; if, however, a *weak* solution be boiled, *water* comes off and the liquid becomes more concentrated. Hydrochloric acid of sp. gr. 1·11 boils at 110° C. The following table shows the amount of pure acid in aqueous solutions of hydrochloric acid of different specific gravities, as recently determined by Kolb. It must, however, be borne in mind that these figures are strictly accurate only in the case of *pure* solutions, and that the presence of neutral salts, such as sodium chloride or common salt, will raise the specific gravity without adding to the strength. Most samples of the commercial acid, however, do not contain sufficient impurities to make much difference.

THE SANITARY ARCHITECT.

THE PRINCIPLES AND PRACTICE OF HIS WORK, IN HEALTHY HOUSE ARRANGEMENT AND CONSTRUCTION.—TECHNICAL POINTS OF SEWERAGE AND DRAINAGE, VENTILATION, ETC.

CHAPTER III.

AT the conclusion of the preceding chapter we stated that damp often gave no indication of its presence, and therefore exercised its bad influence without those subjected to it being aware of its existence. Now, while damp may, and often does, arise from defectively constructed walls, either too thin, or, if thick, too carelessly put together, it much more frequently owes its existence to the foundations of the house having been neglected, using the term in the sense we have already defined it. In nine cases out of ten no attention, or if any, very little, is paid to the condition in which the soil is, and as to what the character of the soil itself is.

It may be of a close retentive clay, catching up and retaining, with the closest of grips, the drainage water of the surface, or that coming from the surrounding and higher placed soil. A site of this kind is the very worst which can be had, and if possible another should be chosen. But if the matter is a case of "Hobson's choice—this or none," every means should be taken to lessen, and if possible do away with, its evils; for unless this be done, there will be little chance of the house being a truly healthy one. The first thing to be done is to thoroughly cross-drain the site; and, indeed, the land for some distance beyond it. Let it be remembered that the drains used are field drains, with open joints, through which the water finds its way, percolating from the adjacent soil to the interior of the tubes; these again joining with a main drain of a larger diameter, and which leads finally to the main drain or outfall.

Sewage tubes are quite distinct from field ones, and are laid upon a different principle, the joints being water-tight, so as to keep the sewage in and allow of no contact with the soil surrounding them. The site should be surrounded with drain tubes, to catch or arrest the water coming in from around it; but if the expense be objected to, it is at all events essential that the side or sides towards the highest land be so provided with a catch-water drain. The actual site itself, and for a little space beyond it, should be crossed in the direction of the fall or inclination of the land by the drains, placed at distances more or less great, according to the retentiveness of the soil, the maximum distance being, on an average, about twenty feet.

The great mistake in draining sites when they have—which we regret to say is but seldom—to be drained at all, is that the drains are too far apart, and far too shallow or too near the surface. The latter arises from the mistaken idea that a deep drain will not draw, as it is called, the water away from the soil; but the fact is, that the deeper the drain, consistent with the limit which difficulty of working and expense will put, the better drained the soil will be. To prevent the drain tubes from getting out of repair—this arising chiefly from their getting out of line with each other—it will be the better plan to use a "collar," this being a short length of tube of diameter large enough to embrace the two drain tubes. The drain tubes themselves should not be put down too small in internal diameter, as they are apt to get silted up with the finer particles of the soil. A diameter of two inches we would place as the minimum. Some soils are so happily adapted for good sites, such as a free gravel with sandy bottom, that no drainage seems requisite; but as even in the best soils there may be cavities or holes or faults in which water lodges, we should strongly recommend even these to be drained, for water lodging, as it will lodge, in any place under or near the site, will in time send up vapour or emanations which are much better absent than present. Prevention any day is better than cure. Of course, in fine dry soils the drains will require to be fewer in number, and not so deep, as in the case of those which are of retentive character.

In concluding our remarks on this part of the subject, let its value be understood from this: that there would be fewer damp houses, and less of the many mysterious complaints which owe their origin to them, the sites were always drained.

Amongst the soils which are to be classed as bad—and the soils of sites range from gravel as the best down to close retentive "bird-limy clay" as the worst—are what are termed made soils, to be met with on those unlucky (for the inhabitants of the houses afterwards built upon them) plots on which is stuck up on a board, "Rubbish may be shot here."

Rubbish in the worst sense it is; and it is difficult to overestimate the evils arising from sites made of it. Some which have been examined by competent authorities have been found to consist or be made up of not merely soil, broken bricks, lime, etc., which are in one sense not bad, but also of vegetable matter, and what is far worse, animal refuse of all kinds, both of which, vegetable and animal, are liable to decay.

Now, this decay gives rise to several classes of evils. First, it allows of the subsidence of the soil at the points at which the decaying matter rested; so that the danger of unequal settlements in the foundations of the house comes into play, causing the walls to settle unequally, and making ceilings to crack, and all the other evils too well known to householders. Secondly, and what is worse, during the period in which the animal and vegetable substances are decaying they emit and send up through the soil foul gaseous emanations, the only outlet in too many cases for which is through the apartments of the house, and the presence of which is indicated by smells the origin of which is not known, or in the majority of cases, not even being suspected, are set down in that category known as "most unaccountable" or "most mysterious," which covers many an evil, and allows those under their influence quietly to submit to, there being apparently no remedy for them.

Again, when once completely decayed, if the soil above does not settle down, holes and cavities are formed, into which water or moisture collects, and this again sends forth emanations—none the better for being mixed with the last remains of the decayed substances—which have their only outlet or escape, as before, through the house, and also cause the soil to become damp, and through this the foundations and walls. And thus the evils go on. But further still, the rubbish is "shot" upon surfaces of the natural soil which have been in no way prepared to receive it—"shot down" upon "hills and hollows," with a supreme indifference to after results—and "shot down" often upon heaps of filth and garbage of all kinds which have been accumulating for a long time upon plots of waste and neglected land.

Taking all these things into consideration—and we have in no way dealt in exaggeration either of cause or effect—need we wonder that houses built upon sites the soil of which is in these conditions named, are unhealthy, cannot possibly be healthy places, for people to live in—especially for women or children, who as a rule live there the whole day, and who, also as a rule, are more liable to attacks of disease than the male inhabitants, who are not subjected for such long periods to the causes, as they have usually to be absent on their business affairs during the greater part of the day? What, then, is to be done in cases such as these we have so very briefly detailed? Why, by no means a difficult thing; but nothing, we venture to say, will be done till employers of labour insist upon what is necessary to be done, being done. It is not that the working details of sanitation are difficult, or so very difficult to be carried out; that they are not, is but simply from the indifference of the parties interested as to their being so. Either indifference or ignorance; and it is only when these are overcome that we shall see a new state of matters introduced. We, of course, are here meant to be understood as attributing the indifference to the employer of labour, who knows what should be done, but who does not care to see that it is done; the ignorance we attribute to the large body of the people generally.

For it is a very curious, and not the least suggestive point in connection with the history of the science of sanitation, that, notwithstanding all the talk, the papers and pamphlets, and the work generally of the press, which has been done and issued, there is still on the part of the people generally a vast deal of ignorance existing upon the subject. There is, no doubt, a species of vague, misty understanding amongst many, that there are things called sanitary evils, which do affect their health, and which in some kind of way are concerned with their houses; but as to these evils, what they are, and how they are connected with their homes, they have no practical idea whatever, and, of course, none as to how they are to be remedied, or if their houses are bad, how they are to be made good.

Those about to build have a vast power with the builder if they please to exercise it, but it is not easy to exercise that of which they are ignorant, or to give orders for things to be done or points to be attended to, if they do not themselves know what these are. But the indifference of those who do know is most highly to be blamed, for with them rests—has rested for a long time—a power to do good which they have failed to exercise. Take the question of site and soil, which we have but very briefly gone into: how easy, comparatively easy, would it be for an employer to see that the evils we have pointed out should be avoided! They can be avoided easily enough—true, at the cost of some time and money, but if these be valued more than the health, either of themselves or of those related to them, there can be no more said—the matter is decided, the choice is made.

But if health be the main object to be secured in the structure of a house—and if it is valued properly it will be so—then the matter is one of comparatively easy attainment. The party who is about to build, say a family house, can insist upon his builder or architect examining the site, and if it is necessary—both of them ought to know at once if it be so—to have it drained; the owner can order it to be done, and it will do him no harm, but some good, if he takes an occasional walk to look after the work himself, and to see that it is being done. He may not be acquainted with practical details, but he will be able, as a general rule, to know whether the work is being fairly done or not. And if he employs (as he should employ) a competent architect, the latter will take care to see that all the details are fully attended to.

Where the site is to be a "made one," the matter in some respects is more easy to be dealt with, for it is not doubtful when real rubbish is used for this purpose. The nature of *that* no man can misunderstand who has eyes to see and a nose wherewithal to smell. Let the soil be good; and if the architect looks after the work he will see that this soil is properly put down, so that no settlement can afterwards take place, or holes and cavities be formed in which water can lodge, the danger of which last we have already pointed out.

To conclude this department of our subject, let it again be understood that the evils created by bad sites are very great, exercise a most deleterious influence upon the health of the inhabitants, and are very easily —too easily—brought into play; but that, notwithstanding, these evils can be in a comparatively easy way avoided by the exercise of a little care, and by the determination that this care shall be exercised by all connected with the practical details of the building.

We have taken into consideration various points connected with the sites of houses. This department of sanitary construction, the reader will have perceived, is concerned with more than one point. The subject of aspect is not the only thing to be considered in connection with the site; this, indeed, is of importance, but it may be said to be in a measure unimportant when considered in relation to or contrasted with the points connected with the soil of the actual site or portion of ground on which the house is built. And on the way in which the architect deals with the actual site, and in strict relation to the walls erected upon it, depends greatly the construction of the house.

Much is said nowadays as to the importance of securing thoroughly efficient house drainage, as an essential factor in the problem of how to construct a healthy home. We shall see in the chapter following upon this how essential this house drainage is; but some little experience in the arrangement and construction of domestic buildings has shown us that, while it is impossible to overestimate the importance of house drainage as a means of securing a healthy home, it is much to be feared that the almost exclusive attention to this department of sanitary construction has caused other points bearing most closely on the health of house inmates to be greatly and in too many cases wholly overlooked. Of these overlooked or neglected points, that of the *prevention of damp in the floors and walls of houses* is the chief in importance. Taking all the evidence which is to be met with—but which unfortunately, as a rule, has not received the wide-spread attention it deserves both from the builders and the occupiers of our domestic dwellings—it may indeed be gravely questioned whether more injury to health has not been caused by damp houses than by those which have been ill drained. A strict inquiry, medical as well as sanitary (meaning by this term the details which come within the province of the architect), would, we feel assured, result in the truth being made very clear that, if not as extensively existing, damp is quite as potent a power for creating diseases and distressing complaints as the foul gases and mephitic vapour arising from defective drains and sewers.

One reason why the evils done to health by damp floors and walls of houses are not so fully and as we may say popularly recognised as those arising from defective house drainage, is probably that they are so insidious and so occult or hidden. That much ill health at one time attributed to other causes, and generally to defective house drainage, has been by clever medical men traced to damp, is beyond a doubt. And we believe that in the future the careful diagnosis of diseases which will distinguish the age will prove conclusively that damp, if not to be feared more than defective drainage, is from its potency for evil to be as much dreaded. The importance, then, of attending to all points which affect directly and indirectly the hygrometric condition of a house will thus be seen, and to those we now briefly direct our attention.

But before going into the immediate details of what may be called the department of the prevention of damp or the securing of dryness in houses, it will be necessary to draw attention to one or two neglected points which have a close relation to the subject of site, and which affect more or less directly the health of the inmates of houses; and in doing so the writer will chiefly follow a paper on the subject which he contributed some time ago to one of the leading scientific journals of the day. The first point to which we would draw attention is the condition in which the surface of soil immediately below the floors is so frequently left by the workmen. It need scarcely be said, in connection with the relation which the floor itself bears to the soil of the site immediately below it, that we condemn utterly the system, but too frequently carried out by builders, of laying the flooring boards or flags in close contact with, or even where they are a few inches above, the surface of the soil, in the case of ground-floor apartments. In few cases is the plan of laying the flooring surface immediately upon or in actual contact with the soil adopted—and that only, as a rule, where stone flagging or tiles are used as the flooring material. But even in such cases, and with such materials, we would most strongly recommend that a cavity or space of considerable depth be left between the upper surface of the soil and the lower or under surface of the flagging. If this be used, by far the best plan to insure a dry floor would be the placing of the flagging upon brick bearing walls or sleeper walls; and in the case of tiles, these should be made to rest upon a layer of dry cinders or clinkers of considerable depth. But, however well suited for the flooring surfaces of lobbies flags or tiles may be considered, we have a strong belief that neither of these are suited to apartments in which work is to be done or people are to live, such as washhouses, sculleries or kitchens. They give at the best a cold comfortless surface; and builders of domestic houses should therefore see that working and sleeping apartments—upon which latter we shall hereafter have a word to say—be as comfortable as possible.

THE STONE MASON AS A TECHNICAL WORKER.

THE PRINCIPLES AND PRACTICE OF, AND THE MATERIALS HE EMPLOYS IN, HIS WORK.

CHAPTER IX.

WE concluded the last chapter by stating that the bars in "leading" into stones should be chisel-notched. To enable these to take the fastest hold of the lead, and to resist the breaking-out tendency which the bar may have by pressure or strain put upon it, care should be taken that the direction of the notches should be such that the teeth, so to call them, formed by the notches will open upwards, that is, against the line of strain tending to pull the bar *g* out of the hole in the stone, or rather out of the lead wedge-block *i*, fig. 54 (vol. ii., p. 150). The pupil will learn from this illustration the value of thinking, even in a matter apparently so trifling as a simple cramp, so that all chances of loss or danger to the work may be avoided as completely as possible. He should ever remember that *no detail of construction is trifling*. He ought to bear in mind that the strength of a structure lies in its weakest point: it may be that this weakest point lies in a bolt, a cramp, or a dowel, or what some would call a trifling detail. This, one of the most important axioms in construction, should never be lost sight of; its lessons are simply invaluable to the constructor. The method of "leading-in" iron bars into stones we have described and illustrated, as in fig. 54 at *g i*, is applicable to all positions of bars. Thus *f h*, in same figure, illustrates how it is applied to a horizontal bar. In "leading-in" horizontal or inclined bars, means must be taken to prevent the melted lead from running out as fast as it is poured in. In point of fact, it could not be poured into the horizontal hole as at *h* in fig. 54. To get over the difficulty a very simple plan is adopted. Well kneaded plaster clay is taken and stuck up and secured against the face of the wall or stone into which the horizontal bar is to be "leaded," the clay being so shaped or moulded by the hand as to form a species of cup open at top, into which the melted lead is poured, which is of course conducted to all parts of the dovetail hole, as at *h* in fig. 54. When the lead is "set" or cold, the clay cup is taken down, and the mass of solid lead left outside the hole is cut away with the cold chisel, and left smooth on surface and flush with the surface of stone or wall in which the iron bar is leaded.

Further Illustrations of the Practice of Cramping by Joining Blocks of Stone together with Iron.

In fig. 53 (*ante*) the use of a "cramp" for securing stones together, as *d e*, is further illustrated by different views; the upper sketch being in plan, the lower to the right, a section in the direction of the length of the stones ("longitudinal vertical section"—see "The Building and Machine Draughtsman"), the lower sketch to the left being a cross or transverse section in the direction of the breadth of the block. A further illustration of the use of "cramps" is given in fig. 57. In this, which shows a "cornice block," *a a*, crossing a wall *b*, which we suppose to be further secured by a stone "dowel" at *c*, the block is secured by the cramp *d d*, of which front view is at *e e*. In place of terminating at a point below the top surface of block, as shown at *d d*, the cramp at upper end may be extended further up, and have a double returned end, as at *f*. This may have a greater or less horizontal hold of the upper surface of block *a a*; in the illustration this hold is very short. Fig. 58 illustrates another method of using cramps. In this two "header" blocks, *a b*, in the cross section of a wall in "coursed rubble work," are secured together to provide for a pressure or strain tending to force them apart, or to cause the wall to bulge out. The "cramp" is at *c c*.

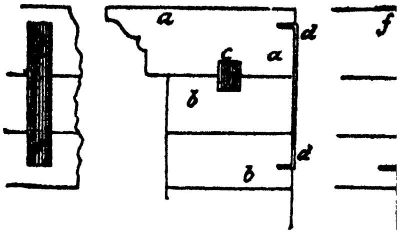


Fig. 57.

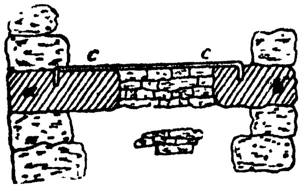


Fig. 58.

Securing or Binding Blocks of Stone together by means of Iron Bolts and Keys or Cottars.

We now come to the last of the methods of supplementary bonding—namely, bolts, and bolts and ties, or bars. And first as to bolts. These are of different forms, and are employed in a variety of ways, the general direction of the bolts being either vertical or horizontal. Both of these are illustrated in the sketches in fig. 59. Bolts are secured in position by two

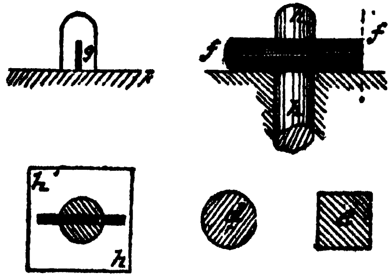


Fig. 59.

methods—either by flat keys or wedges, or by having screwed ends and nuts. The first of these methods is illustrated at *a b*, showing how the stones *c*, *c*, are secured by the vertical tie of the bolt, which passes through a hole made in each stone. This hole is made a little longer than the diameter, if circular, as at *d*; on the side, if square, in section as at *e*,—so as to admit of the easy passing down of the bolt, and of its expansion, which may take place. The lower end of the bolt is passed into a vacant space, as *b*, left in the stonework, to admit of the fastening being put in. This consists of a "key," or wedge, made of flat bar iron, as at *f f*, this being passed through a slot or rectangularly-shaped opening, as *g*, made at the end of the bolt. The position of this slot is such that when the key *f f* is passed into it, the upper edge of the key will press against the lower surface of the stone. The sketches at *f f* and *g*—the first being a view at the side, the second a view of the edge of the bolt and wedge—illustrate the bolt as secured at the *top* or uppermost stone block of the series of blocks, as at *c c*. The position at the bottom of the bolt, as at *b*, is the same in detail, only reversed. This arrangement, although often adopted, is so far faulty that it affords no good bearing surface for the retaining wedge or key *f f*. This presses on the stone only through the medium of its narrow edge. If the stone block be of a soft nature, this edge is apt, under pressure put upon it, to cut into the stone. This fault can be overcome by giving a broad bearing surface of iron, the same material as the bolt and wedge, or key, this surface being simply a flat and thickish plate of iron. As the pressure to which this is subjected is chiefly that of compression (see the chapter on Framing in "The Carpenter"), it may be made of cast iron, which form of the metal is well calculated to resist a strain of this kind. Or the "bearing plate" may be made of a piece of boiler plate. The surface of this should be considerable, so as to distribute the pressure over as large a surface of the stone as possible. The arrangement is shown in plan at *h*. The pupil will find some information as to the value of large "bearing surfaces" in resisting by distributing pressure in the paper under the head of "The Carpenter."

Securing or Binding Blocks of Stone together by means of Iron Screw Bolts and Nuts.

The method of securing bolts in stonework by screwed ends and "nuts," as at *i j* (fig. 59), is further explained in detail in fig. 60. The upper part of the bolt *a a* is screwed, and passes, or should pass, through a "bearing plate," *b b*, bearing or pressing upon the surface, *c c*, of the stone block. A screwed nut, *d d*, passes over and embraces the bolt *a a*, and by turning it, it is pressed down upon the bearing plate *b b*, and by tending to pull the bolt upwards, it tightens down the whole upon the stone surface *c*. But to do this the tendency of the bolt *a a* to be pulled upwards must be resisted. This is done by giving to the lower or opposite extremity of the bolt a bearing surface, as *f*, this part of the bolt being called the "head." As the bearing surface of this is small for the comparatively soft material of stone (for proportion of bolts and nuts see the paper "The General Machinist"), this should itself bear upon a "bearing plate," as *g g*, through a hole in the centre of which the bolt "shank" or "tail" *h* passes, the upper end of which is shown, with its connections, in the upper sketch, to the left in fig. 60,—the plan being below with corresponding letters accented. In place of the bearing plates, as that at *b b*, lying on the surface of the stone, and projecting from it in proportion to its thickness, it may have its surface "flush" or "in line" with the surface of stone by being let into the stone as at *i*; and if the bearing plate have two of its edges "returned," as at *j* and *k*, all the advantages of a "cramp," more or less modified, may be obtained by the arrangement.

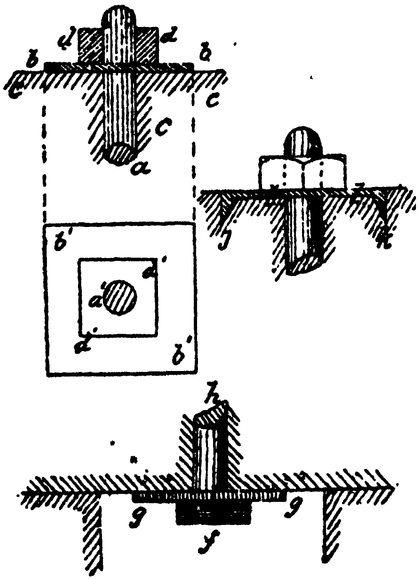


Fig. 60.

Securing or Strengthening Buildings by means of Iron Tie-Rods and Bearing Plates.

Bolts or iron tie-rods with heads and screwed ends and nuts, as now illustrated, are often applied to buildings the floors of which sustain heavy weights, as granaries. Through some defect in construction, either in the walls themselves, unequal settlement of the same, or through defective framing in floors, partitions and roof, the walls, in place of remaining vertical as at *a a*, fig. 61, have a tendency to, and often do, push outwards, as at *b b*. To bring them to the vertical again, or to retain them in this the only stable position, wrought-iron screwed bolts, bearing plates, and nuts are used, as at *c c*.

THE JOINER.

The General Principles and the Details of his Work.

CHAPTER IX.

Resuming our description of the drawing named at the conclusion of last chapter, the second diagram shows a "flush panel," with styles *d d*, the panel having a raised position in the centre, as shown at *a b*, with flat spaces, as at *c c*, all round. The lower diagram to the right is an enlarged view in section and elevation of the part of the panel of upper diagram to the right. The lower diagram to the left is an enlarged view of the left-hand side of the panel, which is technically called a "raised panel." Figs. 5 and 6, Plate XXV., are other views of raised panels; and diagram B in next figure, 58, shows a form of panel in the Gothic. Other forms are illustrated in figs. 1, 2, 3, 4, and 6 in Plate XVII. In fig. 3, Plate XI., the flat part of the panel surrounding the raised central part is called the "margin" (see also fig. 5, Plate XXV., at *b*). The panel, as in fig. 3, Plate XI., is called a "moulded raised panel" when there is a moulding at the margin, as *f e h*. There are other distinctions in panel work yet to be noticed. In "flush panels," as in fig. 1, Plate XI., the "moulding" or "bead" is worked only on the two sides (vertical) of the panel, as at *d d*, fig. 5, Plate XI., and these terminate at the rails, as *f f*, no moulding being at the ends of the panel. This is called "bead butt" panel. When the panel has mouldings all round—that is, at top and bottom as well as at the sides—the mouldings meet at the corners, and are mitred, as shown in the lower part of the diagram in fig. 6, Plate XI.; this is known as a "bead flush" panel. In panel work where a moulding is worked out of the solid, as at *b* in fig. 4, or at *a a* in fig. 5 of the style, as *c c* or *b b*, the term "stuck on" (a corruption of "struck on," which is the true term) is applied. This is only applicable to "bead and butt" panel work vertically, as the mouldings would not mitre if struck horizontally on the rails. When the mouldings are made separately and nailed on to the styles *j j*, and rails *i i*, fig. 6, Plate XI., they are called "laid-on" mouldings. They may be nailed on either to the styles and rails or to the panels in "flush" work, or all round the panels in "square" panels. In fig. 58, in diagram A, we give a panel at upper part of door, in which the upper rail *a a* is curved at top, *b b b* the styles, separated in the centre by a moulding *a a'*; *d* the upper panel, with stuck-on mouldings *c e e*. Diagram B is front elevation of lower panel. In fig. 6, Plate XXV., we give a section of middle style and panel; the middle style *b b* being provided down the centre with a stuck-on moulding, as at *b a*, corresponding to the vertical moulding *a' a'* in fig. 59. A moulding as at *c e* is worked in the margin of the style, corresponding

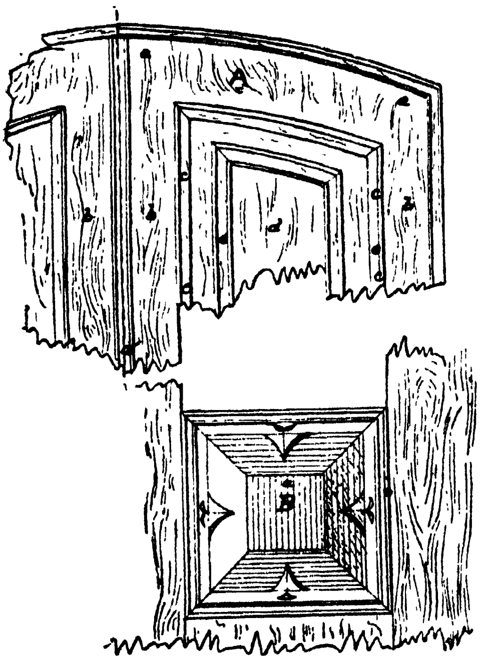


Fig. 58.

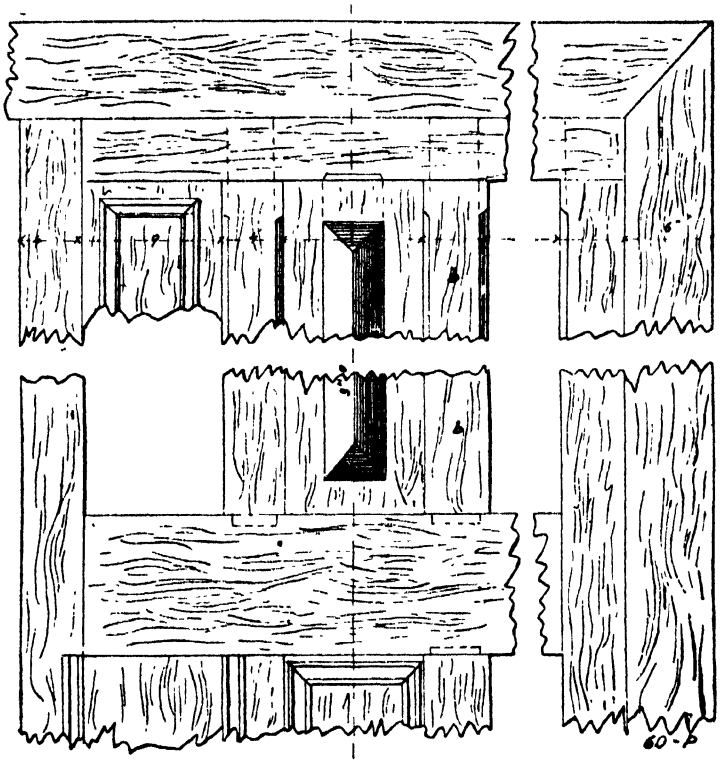
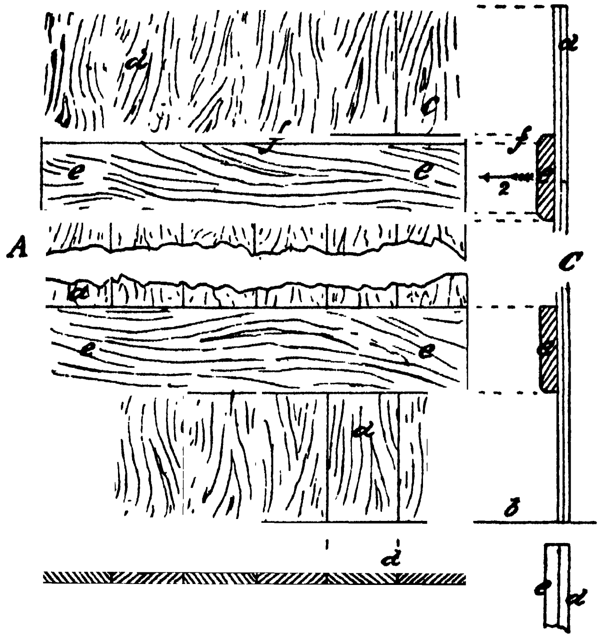


Fig. 59.

to *c c* in fig. 58. *e* shows the moulding in section stuck on the square panel *f g*, the margin *f* being in this way wide. In fig. 59, and in figs. 1, 2, 4, and 6, Plate XVII., we give illustrations of panel work, and in fig. 3, same plate, section and elevation of mouldings for a panel.

Joiner's Work in the Construction of Doors.—Different Kinds of Doors.

We now come to illustrate the different forms of doors, and various details of their construction. Doors are either external or internal, and both may be constructed much in the same way. The chief difference between them, if difference may be made at all, is that external doors are heavier in their timbers—that is, thicker and broader—and are not quite so much ornamented with mouldings, or so highly and carefully finished, as internal or private-room doors. Doors are of different classes, beginning with those adapted either for houses of a simple character, or for out-buildings, etc., where economy is carefully studied, and going up to the more elaborate forms, used in houses of the higher class.



g. 60.

The "Ledged" Door.

The simplest form of doors is shown in part elevation at A, fig. 60, in plan at B, looking down in direction of arrow 1, in C side elevation or edge view looking in direction of arrow 2. This form is what is called a "ledged door." In elevation in diagram A, the lower part is *a a*, next to floor or ground line *b b*. The door is made up of flat planks, *a a c d d*, running vertically from foot or floor or ground line *b b* up to head. These are either laid as in plan B in the cheapest class of work, edge to edge, and held together by cross-pieces or bars *e e*. In better work, these and the vertical parts *d d* are secured by joints of different kinds (see preceding chapter on joints used in joinery). In the section C the cross-bars *e* are simply laid flat and nailed to the upright planks *d d*. The edges of the cross-bars *d d* may either be left square, or have the lines or corners planed off or "chamfered" or bevelled off (see succeeding paragraph), as at *f f*.

Ledged and Braced, and Ledged, Braced, and Framed Door.

Fig. 61 is an elevation in diagram A of a "ledged and braced" door. To the vertical and cross bars of the simple form in fig. 60, the diagonal "braces" *a a a a*, corresponding to the struts of a roof truss, are introduced; these butt against the cross-bars or "ledges" *b b b b*, while behind are the vertical boards *c c c c*. Diagram B is side elevation or edge view, and C vertical section. A still higher class of door is the "framed, braced, and ledged" door in fig. 62: here, as in elevation in diagram A, we have an outer frame of vertical pieces, held together and secured by the cross-bars *b, c, d*, the ends of these being tenoned into the styles *a a*. The central spaces are filled with braces *e e*, and the vertical boards *f f*. Diagram B is vertical section on line 2, and C is edge view, showing ends of tenons of cross-bars *b, c, d*; D is plan of top edge, looking down; E is cross or horizontal section on line 3 4 in A.

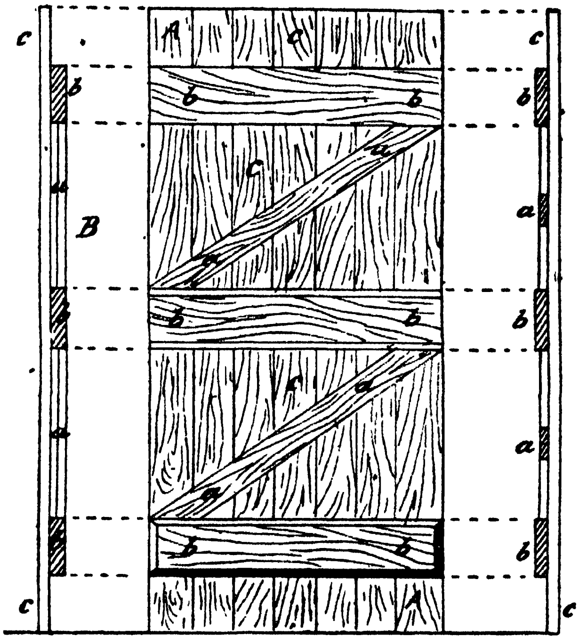


Fig. 61.

THE STEAM ENGINE USER.

THE DIFFERENT CLASSES OF ENGINES USED CHIEFLY FOR MANUFACTURING AND AGRICULTURAL PURPOSES.—THE LEADING DETAILS OF STEAM ENGINES—CONSTRUCTIVE AND OPERATIVE.—THEIR PRACTICAL WORKING AND ECONOMICAL MANAGEMENT.

CHAPTER XII.

To discover the defective setting of the valve, shut off the steam and turn round the fly-wheel until the piston is near the end of its stroke, or in that position where the steam port is just closed and the exhaust opened; then turn on full steam by opening the regulator. If the valve is defectively set, steam will issue from the exhaust pipe.

Having shown how defective interior arrangements of the steam-engine cylinder may be detected, we regret that any information we could communicate to the reader by an article would not be practically useful on the subject of setting matters to rights: this involves mechanical skill as well as mechanical knowledge, and the practical engineer, therefore, will have to be called in. But the information we have given is not therefore valueless altogether; for in matters connected with ourselves, when we feel ill, we send for the doctor; but if we not only feel ill, but know what is the matter with us, and tell the doctor what it is, we simplify his labour very much, and think that we are pretty well advanced in that kind of knowledge. Just so with the steam engine: it is something for the tyro to know how to trace some of its defects after he suspects them to exist.

Various Kinds of Steam Engines.—Notice of Early Engines.

It is proposed in the paragraphs following to give a slight sketch of some of the earlier forms of steam engines, and afterwards, more particularly, to describe the general details of some of the more recent forms—principally for the benefit of those in actual charge of engines, and who are unable to gain access to more elaborate treatises on the subject than this pretends to be.

A steam engine may be considered as a machine moved or driven by steam; and this machine should be considered separately from the boiler or steam generator, though of course it must be evident that the engine without its motive power would be useless, just as much as the elaborate machinery in a spinning mill would be useless for its purpose without the motion given to it by the steam engine or other motive power. Commencing with the engine as constructed by Savery (and for which he was granted a patent in the year 1698), and then describing the improvements made by his immediate successors Newcomen and Watt, we shall be led up to a form of engine very similar in general appearance to the beam engine of to-day, which will then be the subject of our investigation.

In order, too, that young students may be able to thoroughly understand the elementary details of the steam engine, we will, so to speak, take a modern beam engine to pieces, and give sketches and drawings of the various parts, and occasionally compare them with parts bearing the same names, but which will be seen to be sometimes very dissimilar to, and at other times very much like, the parts now in use, and performing the same offices in steam engines of the present day.

Having dealt with the beam engine, we shall then go on to describe other forms of engines, taking typical designs rather than comparing the merits of one with the merits of another maker's productions. Under this head will come vertical, horizontal, rotary, and three-cylinder engines.

The question as to the kind of engine to choose for a given purpose is oftentimes followed up by an engine being employed for the work as ill suited as an engine can possibly be; the result being, as one giving the slightest thought to the matter must readily see, great waste of energy, or straining of machinery,—for if the engine be too small, it cannot possibly do the work of the factory, or if it be too large, the small boiler already there cannot keep up a sufficient supply of steam. There are times when one is to blame just as often as the other; or again, it may be that the engine does not do its fair duty because left in charge of a man without the necessary experience—one who knows little or nothing of the construction and delicate mechanism of the simplest steam engine. So long as the crank is turned round he is quite satisfied that the engine is doing its duty, and he rests quite confident that he also has done his when he has succeeded in making the wheels go round.

Too often it happens that the man who acts as stoker to the boiler also does duty as engineman; and not infrequently these offices are looked upon as the least important part of his daily labours, for he may be employed during the chief part of the day working a printing press, attending to a drilling machine or a lathe, or at the saw bench or the anvil or the grindstone, rushing at intervals to "fire up" or turn on the "feed," or give a little oil to the heated bearings of the engine shaft. Such a man is considered a useful hand. Of course there are men who can turn their hands to almost anything, and do many kinds of work in a mechanical sort of way—who can do odd jobs in the shape of repairs, simply copying what has been done before, without fully knowing why this is so or that is otherwise. Still some of the cleverest men have been brought up in trades and professions entirely different from those with which their names are now identified; and it is not to be assumed that a man who attends to his employer's engine and also to his printing press is totally ignorant of the construction or working of both machines. All men, however, have not the inventive genius of James Watt or George

Stephenson, and it is not to be expected that every engineer or mechanic should look upon it as his broader duty to "invent something." A great deal of patient study and perseverance is required to mature new inventions and ideas. Some must therefore work on in the paths laid out for them by men with longer heads and clearer conceptions of real improvements, doing their daily round of duty to the best of their ability; and such work is of as much importance in its way as the most profound inventions or discoveries of the day. If the following pages are of any assistance in making the duties of enginemen less speculative and more pleasant, because of their having helped to explain or make more clear the various offices of the different parts of a steam engine, the efforts of the writer will not have been in vain.

Savery's Engine.—In July 1698 a patent was granted to Thomas Savery for a steam engine, which he described as an "engine to raise water by fire." The working of the machine will be understood from the diagram, fig. 21, which serves to illustrate the principle without going into the details of its construction.

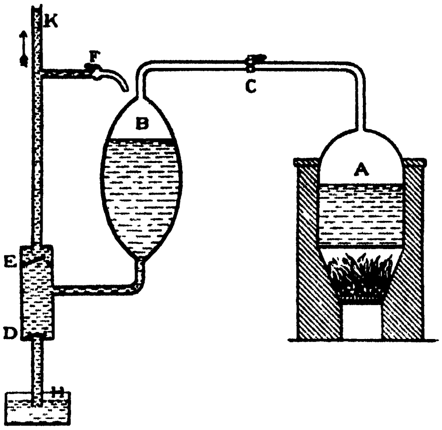


Fig. 21.

Steam is generated in a boiler, A, passing thence into a receiver, B, which communicates with a pipe, H K, leading from a well or river below the level of the engine to a reservoir or tank overhead. Two valves are placed at D, E, each opening upwards, whilst at F is a pipe furnished with a cock, which, when opened, allows a spray of cold water to play upon the receiver for the purpose of cooling it. The action is as follows. The valve C being opened, steam rushes from the boiler, expelling the air from the receiver and driving it through the valve E. The receiver being filled with steam, the valve C is closed, cold water is turned on at F, condensing the steam in the receiver and lowering the pressure therein. The pressure of the external air at H forces a quantity of water up the pipe H, through the valve D, and into the receiver B, nearly filling the latter with water. Steam is once more admitted into the receiver; and this time has the effect of forcing the water which it contains through the valve E and upwards towards the reservoir, as it had previously forced the air. The cock F is again opened, which by cooling the receiver causes a fresh supply of water to flow in, and the operation is continued as before. In the actual engine two of these receivers were employed, one being filled and the other emptied at the same time, thereby keeping up a continuous stream of water pouring into the reservoir.

Experiments made with this engine at Manchester proved that it was a very expensive and extravagant one to work, the loss of heat being very great, and the consumption of coal enormous in proportion to the amount of work done, being at the rate of about ten times the quantity now used by modern pumping engines to perform the same work.

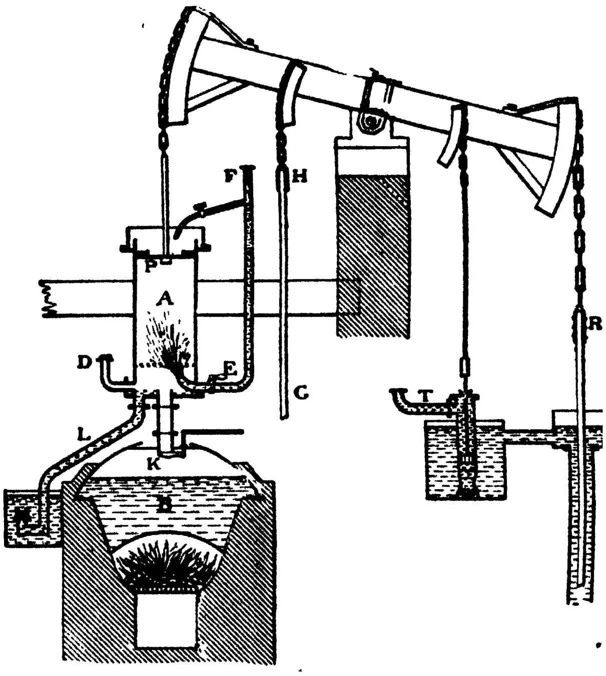


Fig. 22.

It was soon found that engines constructed on this principle were wholly inadequate to the needs of pumping, especially in mines, where the water had to be raised from a great depth. The pressure and supply of steam required for such a purpose would be great—far greater than the steam generators of Savery's time could bear. It therefore remained for others to improve and re-construct.

Newcomen's Engine.—In the year 1712 an engine was set to work at Wolverhampton by Thomas Newcomen, which possessed many features of the modern beam engine. A beam was balanced on its middle point, and to one end were attached the pump-rods, whilst the other was attached by means of a chain to the piston-rod of the steam cylinder.

SUPPLEMENTARY SECTION.

CONTAINING PRACTICALLY USEFUL NOTES, TECHNICAL NEWS, AND CORRESPONDENCE.

TECHNICAL FACTS AND FIGURES IN OCCASIONAL NOTES.

EMBRACING THE VARIOUS DEPARTMENTS OF TECHNICAL AND INDUSTRIAL WORK, SUCH AS MECHANICS AND MACHINE DESIGN AND CONSTRUCTION — BUILDING DESIGN AND CONSTRUCTION—GENERAL MANUFACTURES, AS TEXTILE AND METAL—APPLIED OR MANUFACTURING CHEMISTRY — INDUSTRIAL DECORATION—SANITARY ENGINEERING—GARDENING AND RURAL MATTERS—MISCELLANEOUS.

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149. Ensilage, considered in relation to the Value of its Produce as a Food for Farm Live Stock (see Note, p. 302, Vol. II.).

THAT class to which reference was made in our last note, who always seem much more intent on finding out the weak, or suggesting the possible or probable weak points of a new thing, than on finding out the good points, amongst other objections which they have to silage as a food, have stated that its tendency is to produce costiveness in the animals fed upon it. That this may have been, has indeed actually been observed in one or two cases, we do not doubt; but we know enough of the practice of feeding of stock to assert that careful inquiry and observation should have been given to the question—"Was it the silage food which did actually produce the effect for which it was blamed?" When a new food is given, and a certain effect is produced, it is natural, we confess, to decide at once that it has been brought about by the new food. But a more careful, and in itself a more just and scientific way, is to consider the position all round. And if this be done, it will often be discovered that the effect was not dependent, at least wholly, upon the new food. And on this particular point it is only right to say that all scientific analogy, and indeed all practical experience, goes to point out that the tendency of silage, being a fermented food, in place of being towards costiveness, would be looseness of the bowels. As for us, we should have no fear in using silage in either of these directions; indeed, so highly are we inclined to think of it as a feeding substance, that we consider that not the least valuable of its characteristics is just this one, that by its careful, thoughtful use, a great power can be had by the feeder in adjusting, so to say, the action of the bowels of the animals he feeds. The relative action in this way of different classes of foods has not been studied enough by feeders of farm stock.

In concluding this important section, we have to draw attention to a fact, and to inculcate a principle, which conveys a warning to those who may contemplate making ensilage an integral part of their farming system. The fact is one which bears in a very practical way on the point of the practical value of silage as a food for stock. And it is this. That the experience of all those who have tried silage systematically is wholly in favour of its great value; and that the great American authority on the subject, who has done more with it and in making known the principles and practice of ensilage than any other man, has given most abundant and convincing evidence of the feeding value of its produce to all kinds of stock. We only wish that space permitted us to give an abstract of what Mr. Bailey has published on this specific point.

The warning which in conclusion we offer to the reader, who is careful to read much of what has been recorded on the experience of feeders in the use of silage, is this. In looking over such records—to which may be added, in listening to the *vivâ-voce* statements of different parties who have tried the system—various discrepancies, and not a few absolutely contradictory statements, will be met with. So thoroughly antagonistic and irreconcilable are some of these, that one is apt to doubt the honesty, at least the accuracy of statement, of one or the other of the parties concerned. In looking at the matters however, from the only correct point of view, such discrepancies, and even absolute contradictions, are easily enough explained and reconciled. That the facts of each case are honestly and fairly stated there can be no doubt, but it does not follow that all are named, nor the exact conditions and circumstances of the trial stated, or if so, with the ease and the absolute precision necessary to make the statement of experiments truly valuable.

It is not given to every one to understand the exact principle upon which all experiments depend, nor what is to be done to apply it in such a way as to make the results of practical value. And even when the principle of the experiment is understood, and applied judiciously, and with every care to give its accurate results, accuracy is not always secured. And although in all cases the fact is, or seems to be implied, that the experiment has been made to test the new substance or process with an old and established one—there are in some of the cases not even the first elements of a truly comparative experiment present. We are simply told that the trial of a certain kind was made and with certain results, and that these results were different from others obtained in ordinary practice. But what that ordinary practice was we are not informed. And even where the conditions of a comparative experiment are in so[illegible] respect fulfilled, others are neglected as of no moment, or a certain element is discarded as of no value; whereas it is just as possible a thing as not, that these were the very points on which the value of the experiment turned and depended. Experiments to test the value of one substance as against that of another must be comparative; and to make a comparative experiment valuable at all, the two experiments must be made under precisely the same conditions; otherwise, so far as comparison may be concerned, the trial is worthless. If one wished to test the economical value, say for example of two steam-engines, one would scarcely consider the test to be of much value if in addition to two different kinds of fuel unlike qualities of each were consumed to raise the steam. Some will say that no one would do such a thing as this. But experiments so called have been made with as singular a lack of knowledge as this, and made moreover by scientific men who for the time forgot their science—in putting out the results of a trial of two like machines tried under the most unlike circumstances, as if they had been obtained by a trial rigidly conducted under like conditions.

To arrive at a just conclusion as to the value of a food as compared with another, care in experimenting is even more required than in many scientific experiments in other, and what appear to be more difficult circumstances; and if men of science accustomed to experiments, or who ought to know the logical conditions of such, fail, it is not to be wondered at that some farmers fail also in making their comparative experiments of real trustworthy value. And the conditions of a trial where animals are concerned are of a very complicated character. Where life and all the peculiarities of the living animal come into play as factors in the calculation, points to be of any value require to be carefully watched and attended to, and allowances made. As above stated, a comparative experiment, to be of any value at all, must be made under the same conditions on both sides of the trial. If to test the relative values of two foods, two different lots of animals are used, and these placed under different conditions, the trial or experiment is comparative only in name, and gives nothing to test the relative values of the food. It will show what one food will do with one set of animals, another food with another lot. But *only* this; for the reader will perceive that the nexus or chain which should connect the two foods is wholly wanting, there being literally no connection between them.

Still further, as bringing into all experiments with animals fed on certain substances these elements which give rise to the discrepancies, and even absolute contradictions, we have alluded to, are all those elements connected with the crops themselves which constitute the foods used in the experiments. Silage, for example, is not a substance of a precise or definite quality,—and this even when it is composed of the very same crop. The crop of one district may be, and is likely to be, different in value from the same crop of another district; and even where they should happen to be alike, the way in which they are put into the silo will bring about a material difference in the feeding value of each. And if to those elements of uncertainty all the other elements of a like uncertainty, connected with the way in which the food is given to the animals, the peculiarities of the animals themselves, and the conditions or circumstances under which they are during the period of the trial, one may easily conceive how difficult it is to decide that the value of a trial made in one is to be the value of one made in another district. So far, then, as the value of the ensilage process is to be ascertained for feeding purposes, it appears that with a substance round which so many elements of uncertainty are, so to say, clustered, the farmer must decide for himself by such experiments or trials as he himself can institute. And if some thought be given to what the experiment should be, and some time and care devoted to its details, there should be no difficulty either in the making of them, or in the drawing out from them such lessons as will be of real practical utility in connection with the use of silage for feeding purposes. All this no doubt demands care and time; but if either of those be grudged, it would seem that the farmer has quite mistaken his vocation—has overlooked the first and essential element which goes to the securing of success in any business, no matter what its special nature may be.

But while the uncertainty, which we have above alluded to, exists, and judging from present circumstances will always exist, as to the precise or absolutely definite value of silage, it should be remembered that this is no valid reason for throwing any doubt upon its practical value as adding largely and most efficiently to the feeding substances of the farmer. On the contrary, it should be an incitement to make less doubtful—if that by care and by experiments be possible—what is at present to a certain extent indefinite. Enough is known beyond all doubt to prove that silage, where ensilage has been well carried out, is highly valuable as a feeding substance. And it rests with the farmers to discover the best modes by which it can be well carried out. Nor will it, or rather should it, in any way affect the practical position of the farmer in relation to the value of silage as a cattle food, if after experience over a wide area it should be shown that the analytical or scientific value of silage made from a certain farm produce is only applicable to that particular case, and cannot be taken as indicative of its value, although made from the same crops, if made or siloed by another farmer Ensilage considered as a general feeding substance may not find a place in tables of feeding stuffs, with a definite value attached to it; but that need not concern the farmer very much, if indeed it concern him at all, since he knows that his silage does admirably well for his stock. Nor need it trouble him very much, if at all, that the good results he obtains with it in fattening his bullocks for the butcher, or in increasing the milking capabilities of his cows for the dairyman, are not endorsed by the experiences of another farmer or of other farmers. For if he knows his business well, he knows that the real practical value of food of any kind—and silage is no exception to the rule—is affected, and its feeding value influenced very much, by various circumstances connected with the animals themselves, and by the way in which they are specially or generally treated. All those points have to be considered, and they carry with them the necessity to attend to a great number of details where silage is the food concerned,—a necessity just as much to be attended to as where other and ordinary foods are used.

This last consideration brings us to note the position which silage—and this term the reader will remember is that which denotes the produce preserved in the silo—is likely almost certainly only to occupy. It will not occupy the position of a food or a feeding substance *per se*, or by itself alone, such as a certain grain or a specified root occupies. Its real position is, we believe, this: that it is to be looked upon and used as an adjunct to other foods, and those of the ordinary kind, accepted by all as the staple feeding substances of the live-stock farmer. All experience hitherto obtained leads to this as the definite or ultimate conclusion. Its highest value will, we believe, only be obtained when it is judiciously mixed with other foods. Such experience as we had with the food we preserved in pits, elsewhere described in this section of our work, went altogether in support of this view. As will be seen from what has been elsewhere said, we have a great faith in the method of giving mixtures of different kinds of foods to farm stock. From such experience as we have had, from what we have known of the much wider experience of others, and above all from what physiology has to teach us on the point, we are impressed with the value of variety in food.

And if there be one class of farm stock to which this principle of feeding is possessed of more value than to any other, the class is that of dairy cows. Again and again have we observed that where there has been a falling away of the appetite, at least a lessened zest in partaking of the food—which zest is always a good indication of the condition of a milking cow—we have, by simply changing the food (that is, by introducing variety into the feeding), brought back the appetite, or rather the zest with which the food is taken. For, other circumstances being equal, this sharpness of appetite is an essential in good milk-giving cows. We do not by this mean an absolutely voracious appetite or desire for food; but any one who has closely watched the habits of dairy cows, or method of fattening stock of any kind, will know what we mean by this. We can, if we like, get a good lesson or two on this point from our own personal experience, or from that of our friends. And it would be a good thing for all dairymen if they became impressed with the truth that, physiologically, cows are the same as ourselves, with tastes and likings as to food just as strikingly developed. And there are but few of mature years, possessed of any powers of observation and thought at all, who have not become convinced of the value, from a health point of view, of changes of or variety in food. Of course this system of feeding is one which demands not only more time and attention, but the exercise of more thoughtful care and observation, than the old humdrum method of giving the same food from day to day; and attention is grudged by not a few, while many who do not care to think, or to observe, have not apparently the mental power to do either the one or the other. But where one has a pride in doing one's work well there will be found ample scope and room enough for the exercise of both faculties. We have ever been profoundly impressed with the fact that the most successful dairymen, and the most eminent cattle-breeders, have always been distinguished by the close study they gave to their animals, and the care with which they carried out methods of treatment founded on the results of this thoughtful attention. And, say what the careless and indifferent will, the fact remains nevertheless, that food, and all the points connected with it, is the very base or foundation on which all successful treatment of dairy cows depends. "What goes in at the mouth is what comes out to the milking pail" is a proverb which conveys, if not the whole, the best part of the true principle of dairy-cow treatment. Now, silage, or the produce of silos, lends itself admirably to this principle of variety in feeding. It is presented in the form in which it can be readily mixed with other and ordinary dry foods; and for the preparation of mashes it is excellently adapted. But more than this. When a judicious system of crop culture is adopted, with special reference to the ensilage process, the crops and the silos or pits can be so adjusted that one silo can be devoted to one crop, another silo to a different one. This would at first sight appear to involve a recommendation that the variety of food we have insisted upon was to be obtained by using the silage in bulk—that is, trusting to it alone as the food to be given.

THE CARPENTER Text).

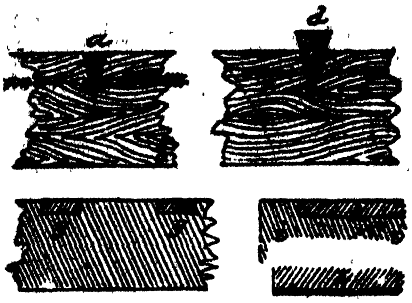


FIG. 1.

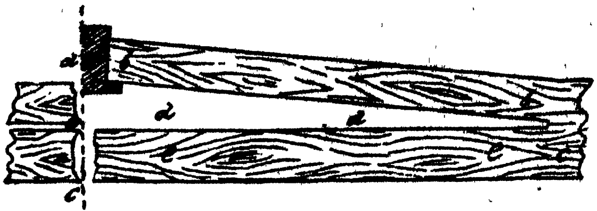


FIG. 2.

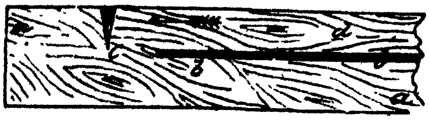
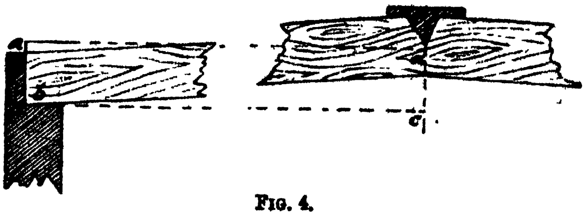


FIG. 3.



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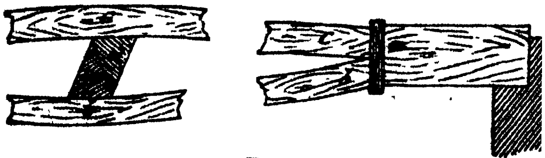

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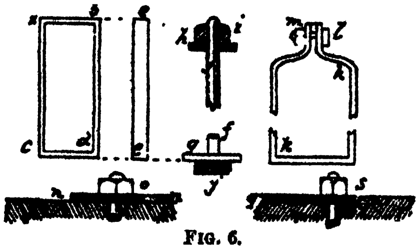

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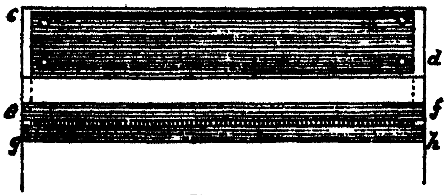

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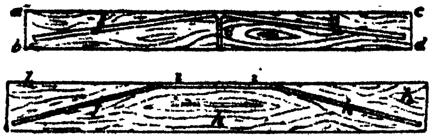
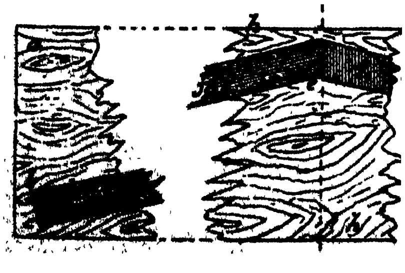


G. 8.



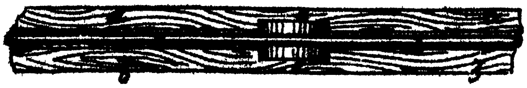


FIG. 10.

THE BRICKLAYER (see Text).

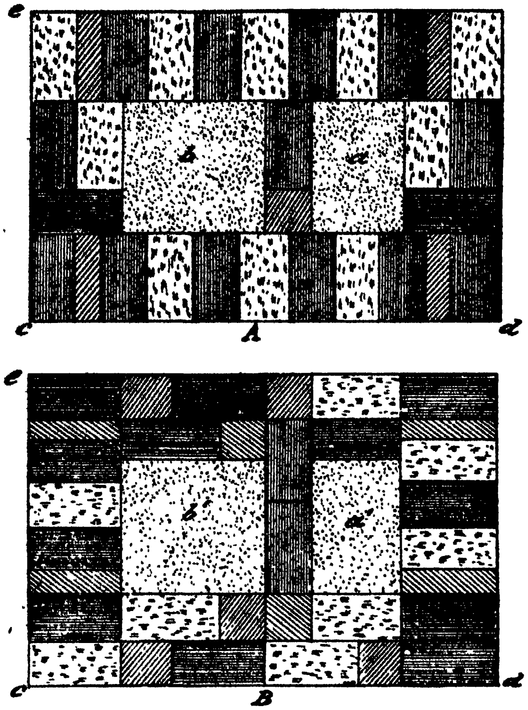
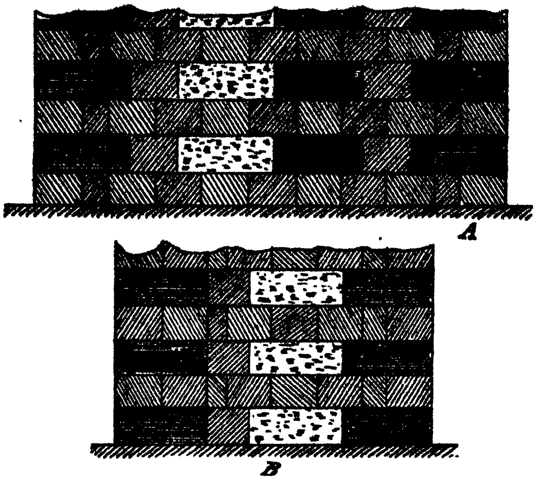


FIG. 1.



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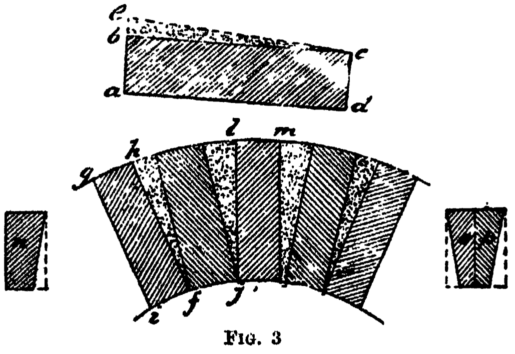

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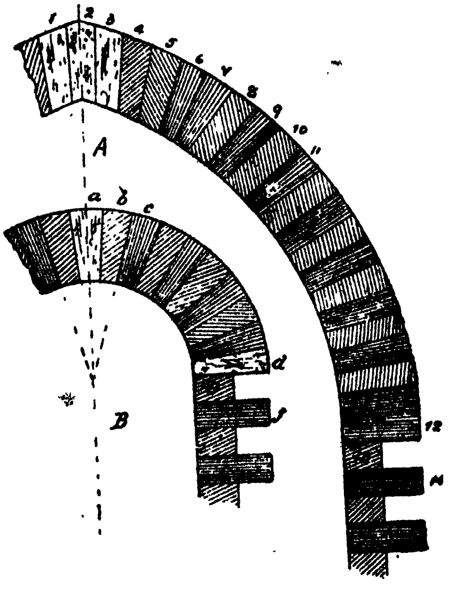

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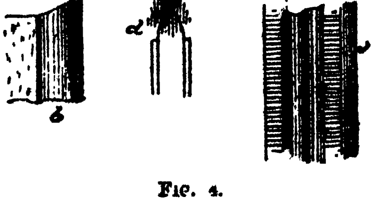


FIG. 4.

THE SANITARY ARCHITECT (see Text).

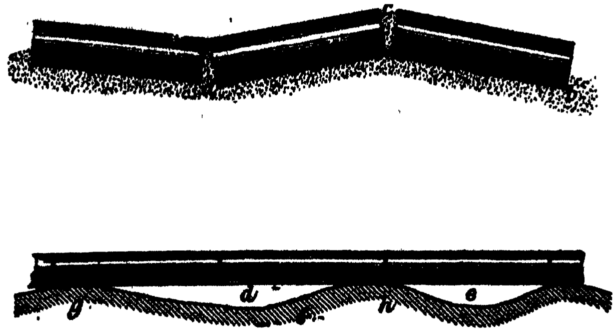
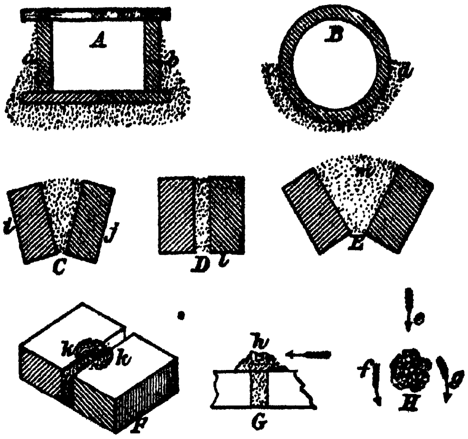


FIG. 1.



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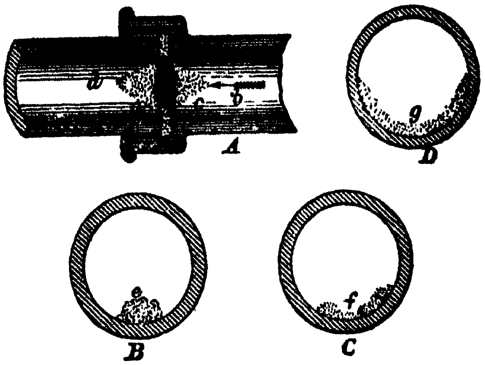
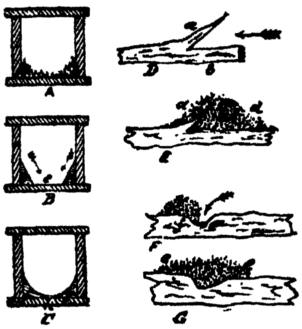


FIG. 3.

NAWAB SALAR JUNG BAHADUR.



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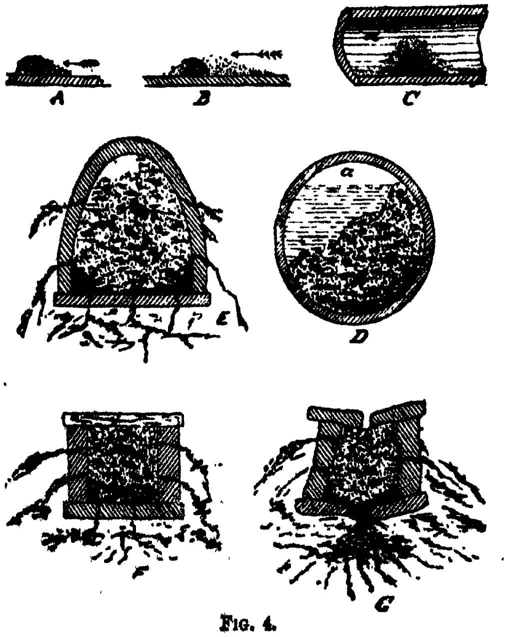

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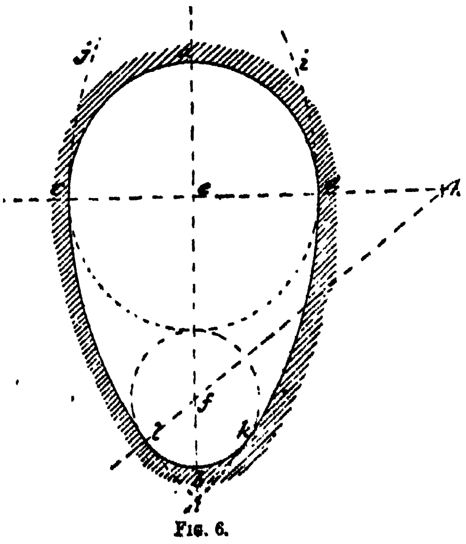

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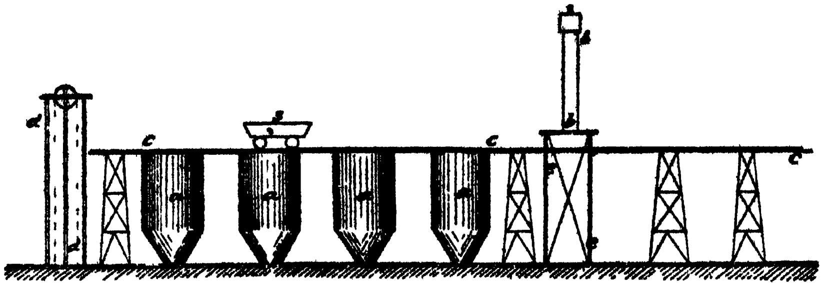


FIG. 1.

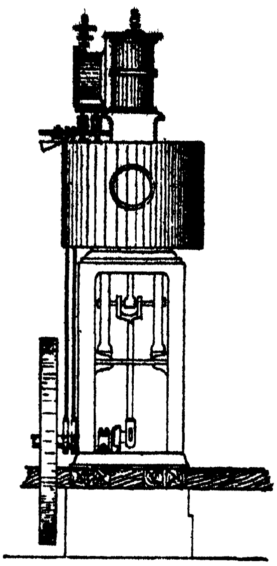


FIG. 8

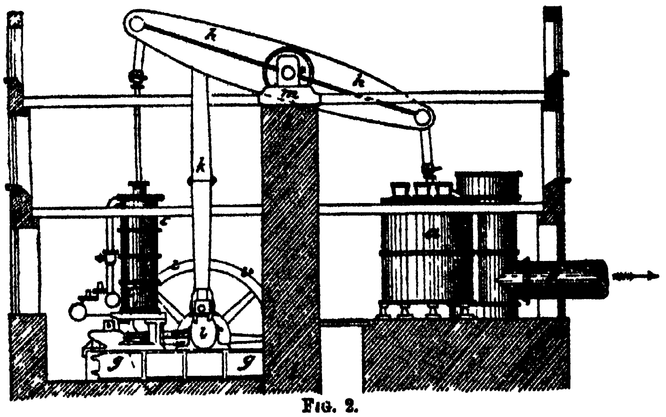
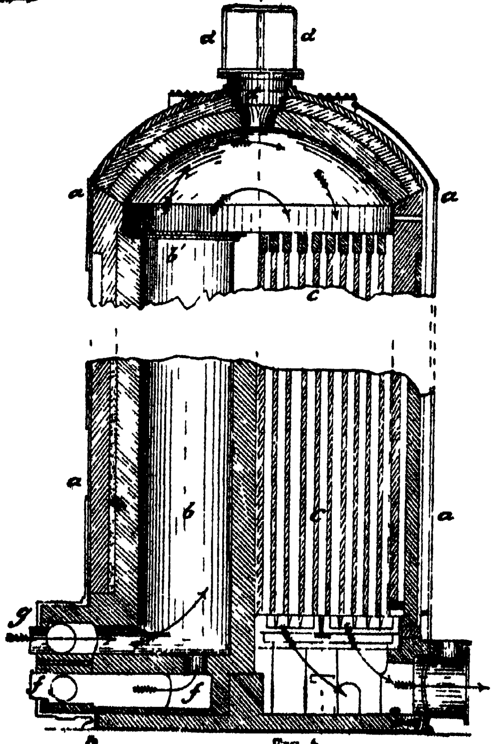


FIG. 2.



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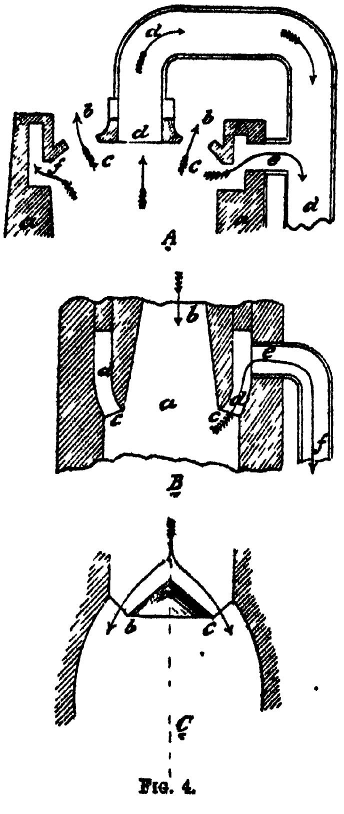
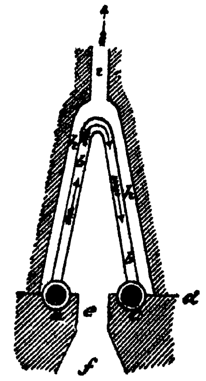


A

B

C

FIG. 4.



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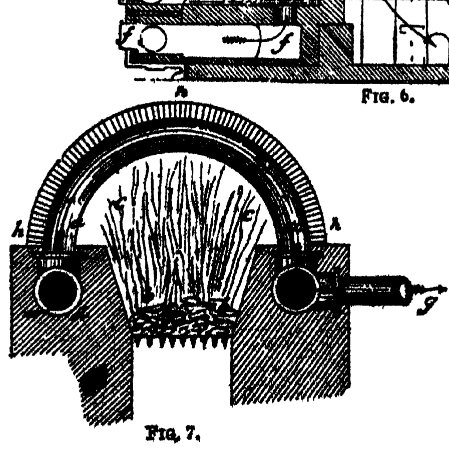


FIG. 7.

THE BUILDING AND MACHINE DRAUGHTSMAN (see Text).

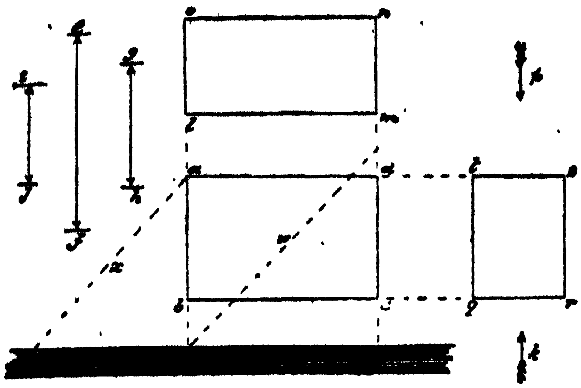


FIG. 1.

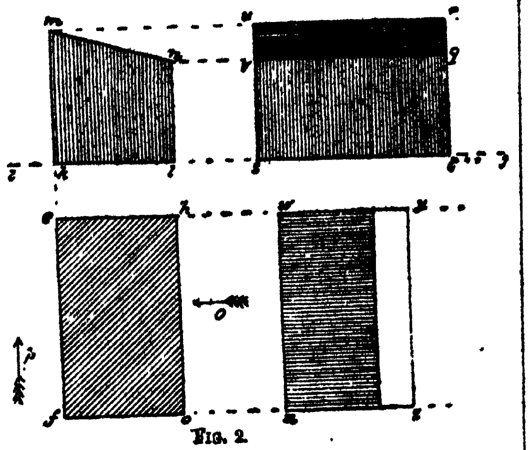
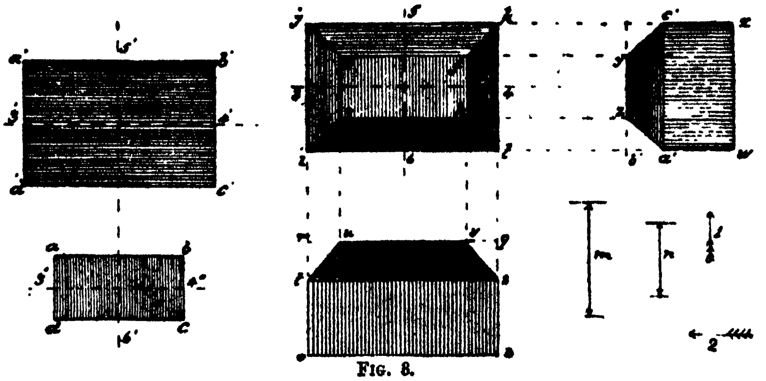


FIG. 2.



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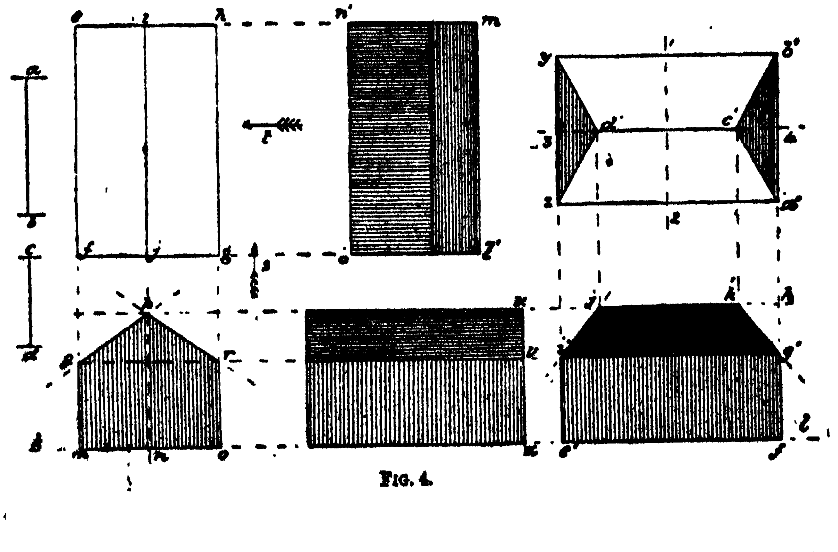

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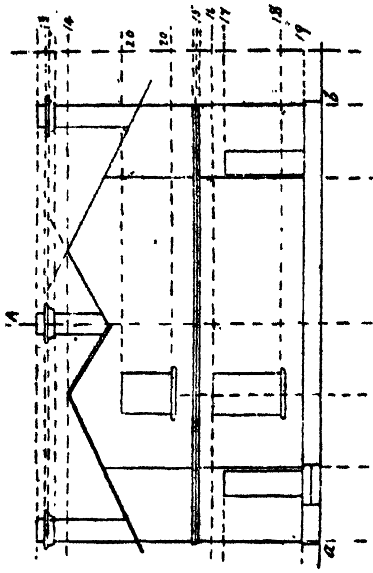

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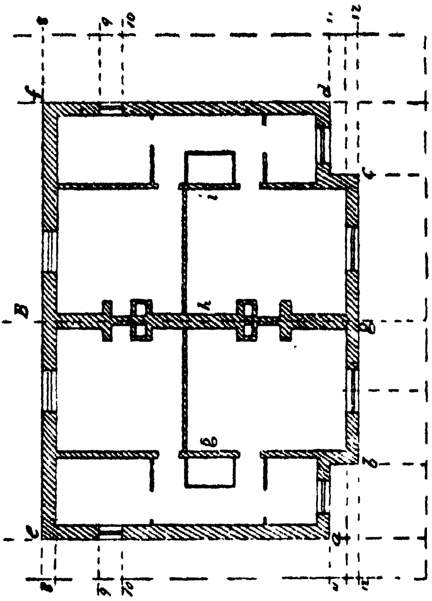

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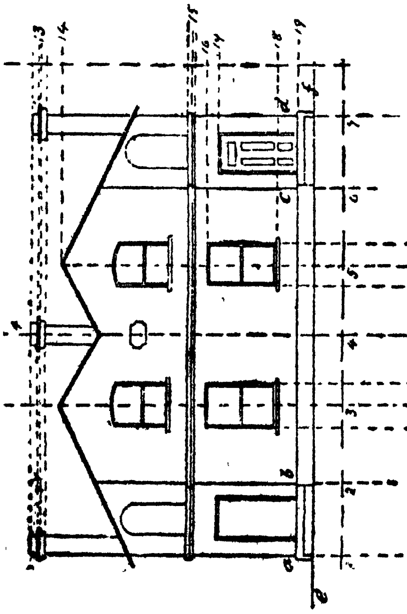


FIG. 1.

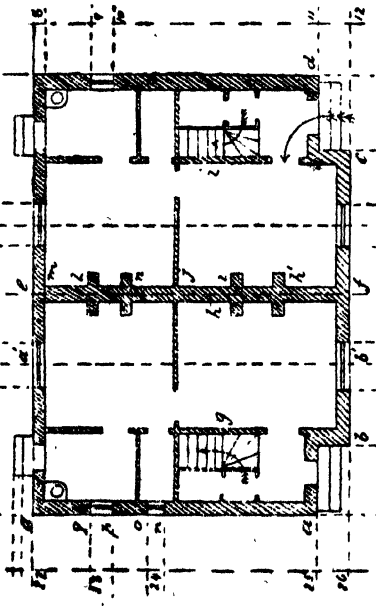


FIG. 2.

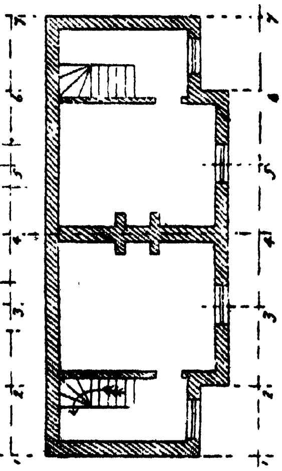


FIG. 3.

THE DOMESTIC HOUSE PLANNER (see Text).

PLANS OF HOUSE ELEVATION IN FIG. 2, PLATE LXXXVIII.

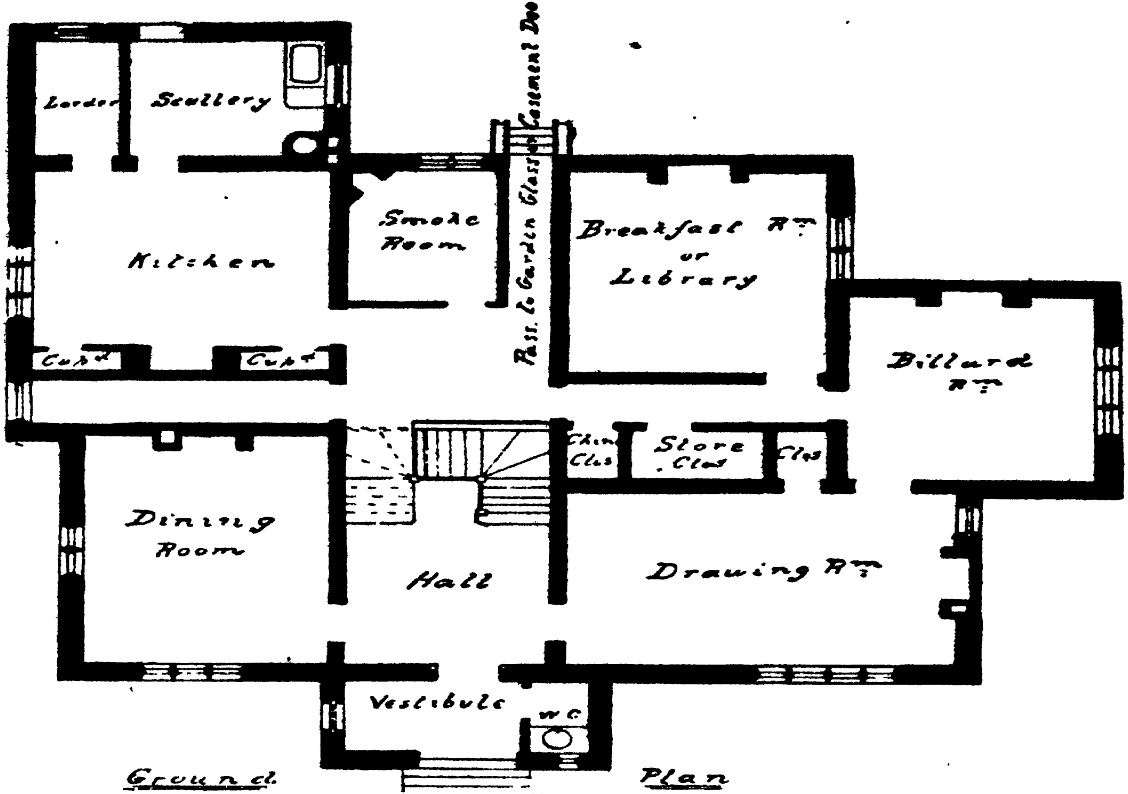


FIG. 1.

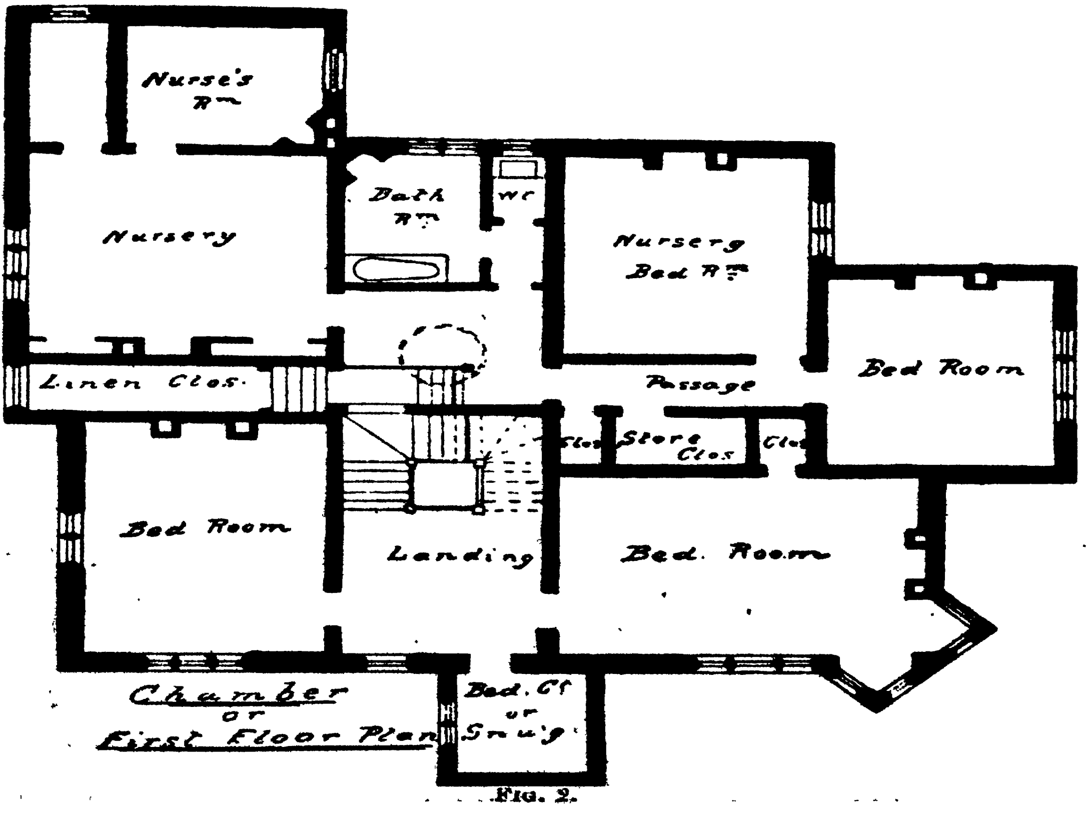


FIG. 2.

THE DOMESTIC HOUSE PLANNER (see Text).

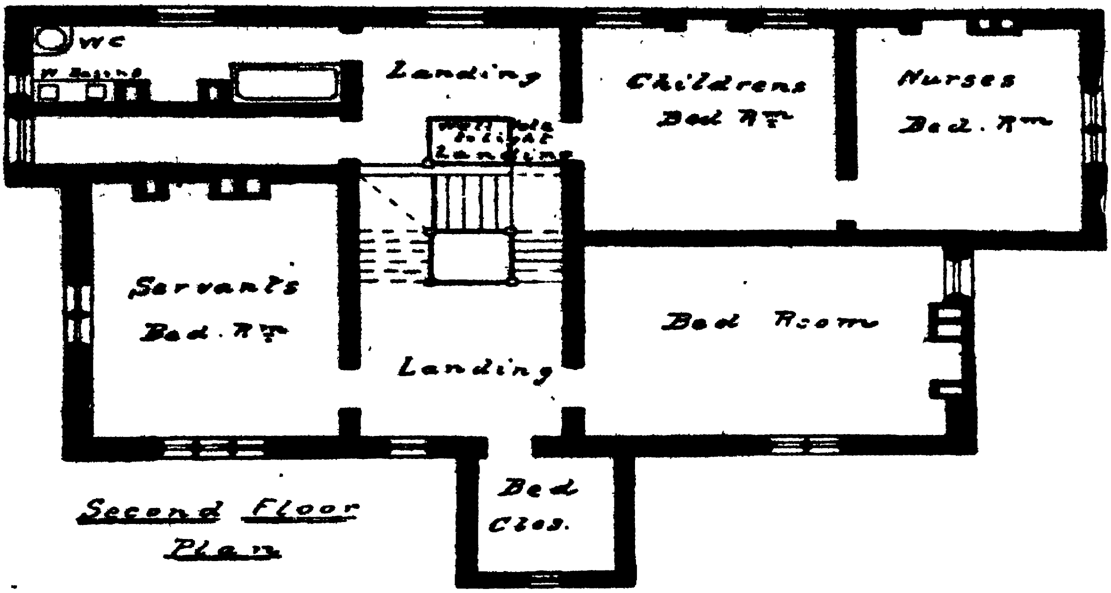


FIG. 1.

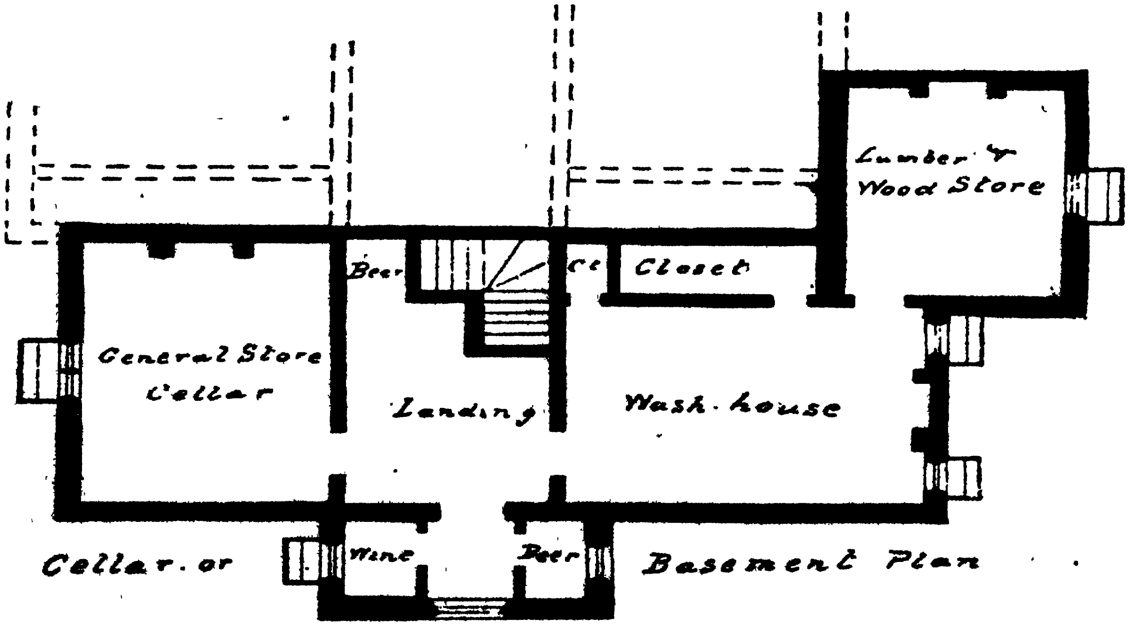


FIG. 2.

THE DOMESTIC HOUSE OR HOME PLANNER OR DESIGNER.

THE WORK OF THE YOUNG ARCHITECT OR BUILDER IN THE DESIGNING OF HOUSES FOR TOWN AND COUNTRY.

CHAPTER IX.

AT conclusion of last chapter we stated that much greater attention was now being paid to the planning of street houses than was at one time given to the subject. And this more systematic and fuller attention to planning displayed in the houses of a superior or of the highest class of street houses may be attributed to the fact that their cost involves, on the part of their owners, a necessity to employ educated architects. In the case of the middle class of street houses, and specially of those immediately below them, their building has, as a rule, fallen into the hands of the speculative class who "build to sell," and who are quite content to follow year after year the track, but all too well and too long beaten, in which their predecessors have gone. So that in the latter class of street houses we may be said to possess but one stereotyped system or method of planning.

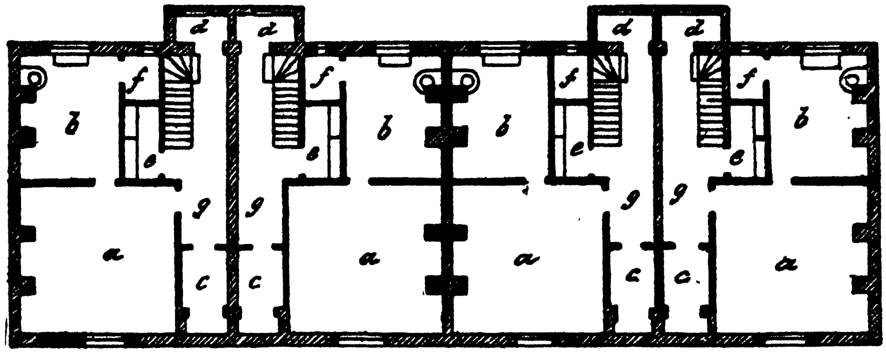


Fig. 1.

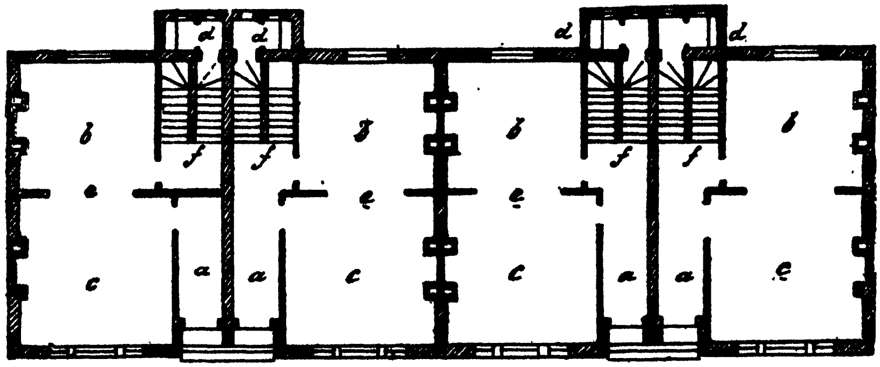


Fig. 2.

A General Improvement necessary not only in Houses of the Working but in those of the Middle Classes.

It certainly is a curious feature of our social economy that, while so very much has been said as to the improvement of the houses of the working classes, so little of the attention of those interested in the general question of domestic sanitation has been given to the question of the improvement of the houses for the tradesmen and the middle classes, that practically it may be said that the question has as yet no existence. And yet it is simply the fact that if there be a necessity to improve the houses of the working classes—and this no one denies—there is as great a necessity to improve those of the tradesmen and middle classes. Some, indeed, who have experience enough to entitle their opinion to be received with grave consideration, assert that there is in fact a greater necessity for improvement, and that as a rule the houses and cottages of the working classes are, with all their admitted faults, better adapted to meet their wants and their circumstances of living than are the houses of the tradesmen and middle classes to meet their necessities. Be this as it may—and there is a greater amount of truth in it than many may be disposed at first view of the case to admit—certain beyond all doubt is it that there is vast room for improvement in the classes of street houses which are inhabited by the tradesmen and middle classes. Of those, especially in the Metropolis, designed or, as we should rather put it, constructed or built for people of moderate incomes, it may, without almost any exaggeration, be said that their main characteristic so far as planning is concerned is their lamentable deficiency in all that is calculated to afford comfort and to add to the conveniences of household life. We say nothing here as to what they possess in the way of sound construction or of healthy sanitary arrangements. Of but too many of them it may be, with all truth, said that those they scarcely possess at all.

Suggestive Plans of a Street House on the English System of Separate Houses.

In Figs. 1, 2, 3, 4, 5, and 6, we illustrate the street house on the English detached house system adopted for streets or for suburban roads, and we contrast those with a house on the Scottish "flat" or "one-floor house" system in figs. 8, 9, and 10, and further illustrated in other plans presently to be described.

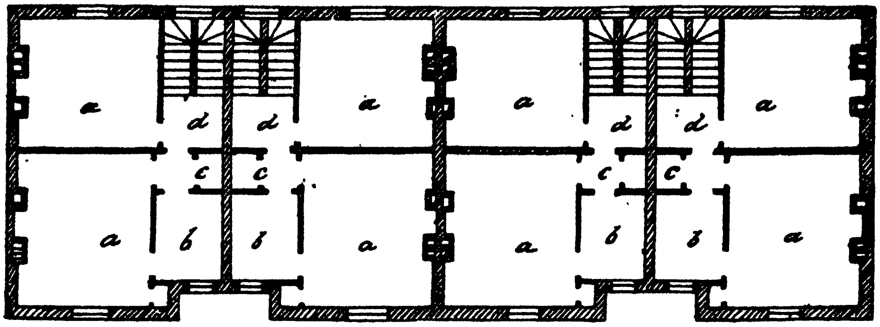


Fig. 3.

And first let us describe the figures illustrating the street house on the English, or separate, or complete house system. The design selected is for a house of three storeys or "floors," as they are designated technically. Fig. 1 is the *basement* or *cellar floor* (first storey or floor), in which the letters *a a* indicate the "kitchen," *b b* the "scullery" and "wash-house," with copper or boiler and slop stone or sink at window, *c* the "coal place," *d* the "knife and boot-cleaning closet," *e e* "larder or store closet" at foot of stairs leading to ground floor, *f f* "china closet," a store closet in scullery or wash-house. Fig. 2 is the *ground plan* (second storey or floor), in which the letters *a a* indicate the "entrance hall or lobby," *b b* the "parlour or sitting-room," *c c* the "drawing-room," *d* water-closet, *e e* space for folding-doors between sitting and drawing-room, *f f* "staircase" leading to the "one-pair plan" or "first floor" (third storey, fig. 3), in which the letters *a a* indicate the "bedrooms," *b b* the "dressing-rooms," *c c* "linen closets," *d d* "landing" at foot of stairs, leading to the "second floor" or "two-pair plan" (fourth storey or floor), shown in fig. 4, in which the letters indicate corresponding parts on fig. 3, the "one-pair plan." Fig. 5 is front elevation, showing a block of four houses; fig. 6, back elevation, of which the details will be given further on when we describe details of houses. Other examples of street houses on the English system will be given hereafter under different classes. Fig. 7 is the scale to which figs. 1 to 6 are drawn.

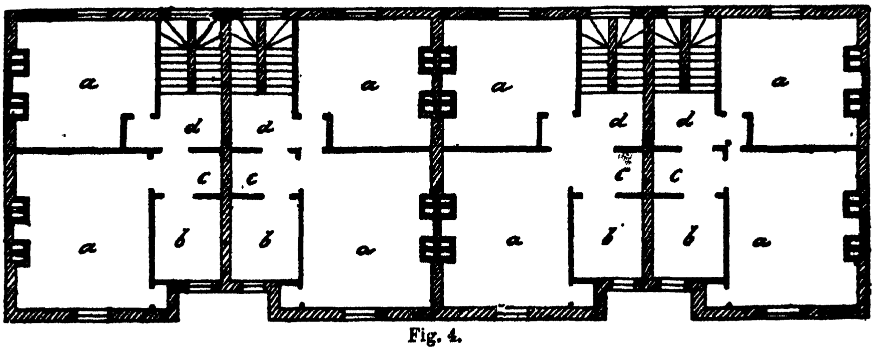


Fig. 4.

The Scottish Style—or Flat System—of constructing Street Houses.

Apart from the details of the plan by which the accommodation of street houses is arranged to suit, or not to suit, the real and the absolutely necessary conveniences and comfort of household life, the principle or system followed in the constructive arrangement of the accommodation, although it may be said to be universal in our country, in reality does not exist in an important part of it—that is, Scotland. There exists in that country a system of construction wholly different from that adopted universally in England, and of which the most handsome examples are of course met with in the Metropolis. It will be necessary to go somewhat into detail as to these two systems of street house construction.

THE BUILDING AND THE MACHINE DRAUGHTSMAN.

CHAPTER XIV

At the end of last chapter we stated that the interior disposition of an object may necessitate several sections, both horizontal and vertical. Thus, in horizontal sections, we might suppose a body to be made up of a series of layers superimposed one upon the other. Thus, the projection in *q r s t*, fig. 27 *ante*, might be the section of one part taken on the line *i j*—the sections of the other parts taken on lines parallel to *i j*; showing the peculiarities of internal arrangements as in the diagrams *a b c d*, *e f g h*, and *i j k l*, in fig. 28. The same peculiarity in construction of the object projected at *a b c d e f g*, fig. 27, might characterise its width or breadth in the direction *c d*, the block being made up of a series of vertical parts placed and secured together face to face, each part having its own peculiar internal arrangement, one of which is shown at *m n o p*, the other might be arranged as in the projections in fig. 28. The two classes of section now described are all taken longitudinally, or in the direction of the length of the object, as *a b c d e f g*, fig. 27. We now come to the third class of section, taken transversely to this direction or across the breadth or width of the object, as in the direction of the line *k l*, fig. 27; the sectional or cutting line extending in the direction at right angles to this—that is, in a vertical direction. Sections of this kind are of great practical utility, as showing certain peculiarities in bodies which could not be shown in one or other of the sections we have already described. Thus, while the horizontal section or sectional plan in projection *a b c d*, fig. 28, gives the peculiarity of the hollow part or vacuity, so far as the horizontal face of the section is concerned, it gives no data whatever as to what is the form or measurement of the part as it exists in relation to the depth or height of the block or body in the direction of the line *c f*, fig. 27. What this map be will be seen if we suppose, as before, the body *a b c d e f g*, fig. 28, to be cut by a line *k l* 10, into two parts removing the left-hand part, we have the face or end of the second part: exposed. This might present the appearance as shown in the projection *a b c d*, fig. 29, or it might be as in that at *e f g h*, or at *i j k l*. Or all these peculiarities might exist in the one block by supposing, as before, that its length, as *a d*, fig. 28, was made up of a series of parts planed and secured together face to face, each part having its own shape or form of its vacuity or hollow space as shown in the diagrams in fig. 29. Those sections being taken in lines transversely or across the breadth or width of the block or body, as in the direction *k l* 10, or at right angles to the line *g f*, fig. 28, they are termed or titled by the draughtsman “transverse” or “cross” sections: thus the section *a b c d*, in fig. 29, would be named a “cross section on the line *k l* 10” (figs. 27, 28), or a “transverse section on the line *k l* 10.” And as the cutting line is vertical, some draughtsmen would use this word, making the title a “transverse (or cross) vertical section on the line *k l* 10.”

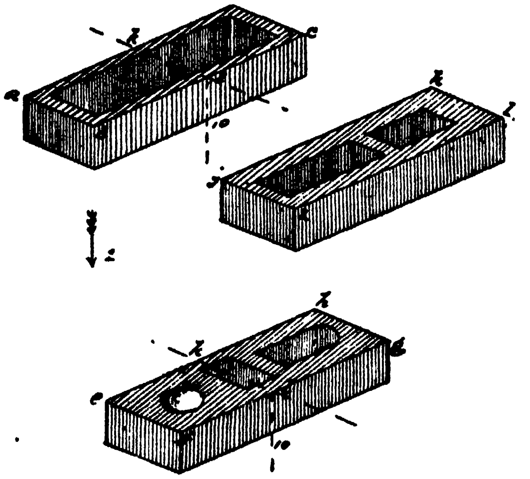


Fig. 28.

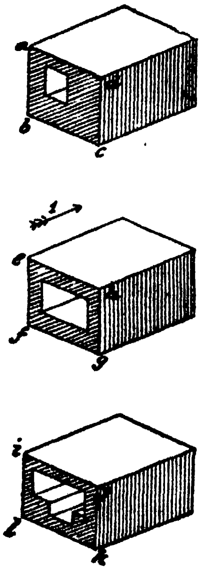


Fig. 29.

All the sections given in figs. 27, 28, and 29, are shown projected in the conventional perspective mode of delineation which we have adopted, as this gives the most graphic illustration of certain points essential to be remembered in acquiring a knowledge of the principles of projection. But as we have already in general terms stated, and as will be more fully explained further on, “working drawings” are not prepared in any method of pictorial representation which perspective gives, but are all delineated or projected in right or straight lines parallel to, or oblique to, or at right angles to one another, on flat surfaces known as planes of projection. And although these planes are in relation to each other as illustrated in fig. 26—that is, vertical and horizontal—still in practice they are spread out on a flat surface as in fig. 25. This is further illustrated in figs. 27, 28 and 29, and in fig. 30—the projection in the latter figure being executed or delineated in the usual style adopted in the preparation of working drawings. Thus, in fig. 30, *a b c d* is the projection of face of section of the block or body *m n o p* in fig. 27, when the latter is looked at in the direction of the arrow 2; *e f g h*, fig. 30, is the projection of the face of section in *q r s t*, fig. 27, when looked down upon in the direction of the arrow 1; *i j k l*, *m n o p*, *q r s t*, fig. 30, the projection of *a b c d*, *e f g h*, *i j k l*, in fig. 28, when looked down upon in the direction of the arrow 2. All these are longitudinal sections; the diagrams in *u*, *v*, and *w*, fig. 30, are projections of the diagrams in fig. 29, which are all cross or transverse sections, as seen in looking at them in the direction of the arrow 3 in fig. 27, or arrow 1 in fig. 29.

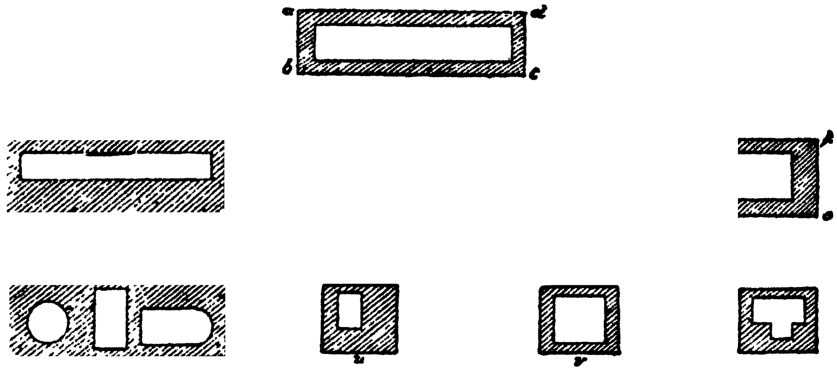


Fig. 30.

Those projections in fig. 30 (see also figs. 24 and 25) are termed plane projections or projections in planes; and the various projections required to show the arrangement of parts and the construction of any given object, while drawn or delineated or projected on a flat surface, as a sheet of paper, are placed in certain relations to one another, so that one will elucidate the parts of another. This principle in projection or drawing has been partially illustrated in fig. 26. But we now proceed to more fully explain it, as upon its due understanding depends the efficiency or otherwise of the architectural and engineering draughtsman. To the beginner the subjects now to follow under this head may appear so simple that he may consider himself quite justified in skipping them over in order to get at the more complicated subjects to be given, as explained in the plan of our papers at end of Chapter I. This may appear a gain of time to him; but if he will be influenced by the experience which has extended over many years of practical work in drawing and designing, we would counsel him not to be led away by any such notions. We can assure him that, so far from gaining, he will but lose time by thus skipping over the simple subjects which are strictly essential to the understanding of the difficult ones. And if, as is the case with most beginners, who are too often eager to try their hand on complicated subjects, he will rush on to these, he will find that he will have to retrace his steps, and this at the loss of much time. For he will find that he has thus much to unlearn, which might have been avoided by going on from simple to difficult subjects, step by step. The importance of being able to do simple work, to understand first principles in acquiring knowledge of any kind, has been pretty well enforced by the author of the paper under the head of "The Ornamental Draughtsman." To this, therefore, we refer the reader, only informing him here that, simple as the subjects are which are now about to be given, each one of them has been designed to serve a special purpose, all leading up to the more special and difficult subjects which will make up the matter of future chapters.

The first example in further elucidating the practice of projection illustrates how the object is projected from given dimensions. The diagram in fig. 1, Plate CLVII., is supposed, at *a b c d*, to be the plan of the bottom of a box, the length of which is to be made equal to the line *e f*, the breadth or width to be equal to the line *g h*, and the depth from top to bottom, or height when standing on its base, to be equal to the line *i j*. The elevation of the side, looking at *a b c d* in the direction of the arrow *k*, is shown at *l m n o*, the end elevation at *q r s t*.

In the preceding chapter we gave illustrations of how the different views of an object are projected on different planes, those being shown in a conventional perspective, so as to make clear the relation in which the planes of projection stand to each other. We also gave illustrations explaining the varieties of views of objects required when the objects are to be constructed, which views make up the series to which the general term of "plans" is applied, or more precisely and generally, working drawings.

How those different projections are obtained on a plane surface, we now show. We assume, of course, that the youthful draughtsman is provided with all the appliances and instruments we have described in Chapters I. and II.; and that he has fixed to his drawing-board a sheet of paper of such dimensions in surface—that is, in length and breadth—as will give him "ample scope and verge enough" for the execution of his work. On this latter point he must understand that he is to project his different views of the objects of the following illustrations to a very much larger scale (see a succeeding chapter for description of "scales for drawings," and the methods of using them) than that we give in our pages. We make our illustrations as large as possible—avoiding the painfully minute diagrams so frequently employed by some writers on technical subjects—still it is obvious that the size of our page and the demands made for space where so many subjects, all elaborate, as a rule, in character, are treated, will alike limit us to a size of drawing very much less than, under other circumstances, we would but too gladly have adopted. Where the lines and their cutting or intersection are numerous, the scale or size of the drawings projected by the young draughtsman should be much larger than when the subjects are more simple—that is, possessed of broader lines, and those less frequently cutting or intersecting each other.

Having adjusted his T-square to the drawing-board so that its blade runs along the length of the board from the right hand, at which the head or stock is placed—the draughtsman is first to draw, at a convenient point on the surface of the paper, any line of indefinite length, as *b c*, fig. 1, Plate CLVII. Taking the distance *e f* in the compasses, it is set off from any convenient point, as *b* in this line, to the point *c*. Then taking the "set square" (of 45°), he adjusts it, as shown by the dotted line *w*, to the upper edge of the blade of T-square, shown partly, and draws along the end edge of the "set square," which is made to coincide with the point *c*, any indefinite line, as *c d*. Sliding the set-square along the blade of the T-square till the line or edge of end coincides with the point *b*, a second line of indefinite length is drawn from the point *b*, as *b a*: this will be parallel to the line drawn previously from *c*, as *c d*. Taking the distance *g h* in the compasses, this is set off from the point *c* to *d*. Then shifting or moving up the T-square till the upper edge of its blade coincides with the point *a*, a line is drawn from *a* towards line *d c*, cutting it in the point *d*. The outline or surface thus drawn, as *a b c d*, is the projection of bottom of the box—which is technically termed a "plan of bottom," and is a delineation of this, as given in a horizontal plane of projection (see figs. 16, 18, and 19). As the dimensions of this plan are equal to the distances *e f*, *g h*, and those are capable of being measured from any scale of equal parts, as that invariably adopted by artificers—namely, the scale of feet and inches and parts of those,—in place of having lines given him, as *e f*, *g h*, the length of those in feet and parts of feet (inches), or in inches and parts (eighths and sixteenths) of inches, might be written out as data for the young draughtsman—as in this case the dimensions or length corresponding to *e f g h* in fig. 32 might be too great for the sheet of paper to contain, or conveniently contain, the drawings projected—a "scale" would have to be adopted. The practical points involved in this term scale, and how they are carried out in practice, will be explained in a future paragraph.

Proceeding with the projection of the drawings of the box, to be given as in fig. 1, Plate CLVII., we have, in the projection of "plan of bottom," data by which the other views or projections are obtained (see fig. 26 and accompanying description). Thus the "side elevation" at *l m n o* is obtained by producing from points *a d* lines parallel to one another and at right angles to *b c*, cutting a line *l m*, which is drawn at any convenient point on the paper above the line *a d*, in the points *l* and *m*. As the upper edge of a drawing-board, placed on the desk or table for working, is technically called the "top," any point over a given line drawn on the paper on its surface, as *a d*, is said to be "above" the line.

From the points *l* and *m* draw lines perpendicular to *l m*, as *m n*, *l o*, and make these equal to the line *i j*, in *m n l o*. Draw through points *o n* a line parallel to *l m* or *a d*. The elevation *l m n o* of side of box will be obtained, as looked at from the direction of arrow *k*. The object being rectangular (see "The Geometrical Draughtsman"), the elevations of the two sides will be the same as at *l m n o*: as, for example, the elevation of the side *a d*, looking at it in the direction of the arrow *p*, will be the same as at *l m n o*.

As the "plan of bottom, *a b c d*, has thus afforded data by which part of the dimensions of the "side elevation," *l m n o*, has been obtained, so will it give further data useful in the projection of the "end elevation" at *q r s t* in fig. 1, Plate CLVII. This is obtained by first drawing a line of indefinite length, as *q t*, at any convenient part of the paper surface on the board, and parallel to *c d* or *a b*; and thereafter producing the lines *a d*, *b c*, till they cut *q t* in the points *q*, *t*, and proceeding as in the finding of the elevation *l m n o*, the distance *q r* or *t s* being equal to that at *i j*. We have thus three views of the object projected, which would be quite sufficient for an artificer to work from in making the box, so far as its external form or configuration is concerned. But the box might be so formed that another view would require to be projected.

THE TECHNICAL STUDENT'S INTRODUCTION TO THE GENERAL PRINCIPLES OF MECHANICS.

Laws affecting Natural Phenomena—Matter and Motion.

CHAPTER XVIII.

At the end of preceding chapter we pointed out how, in the case of a man receiving the blows of a heavy hammer through the medium of an anvil resting on his chest, and in the case of the foundation of a steam hammer receiving its ponderous blows, the force or the momentum of the blows was diffused, so to say, through the mass, so that the velocity was reduced to a mere trifle. The elasticity of the muscles of the chest of the man in the one case, and the fibres of the foundation of the steam hammer in the other, render it practically innocent of danger either to the life of the one or the mechanism of the other, which would be endangered in both instances were not means taken to bring into play the influence of time and space.

But much as has been given in this present general paragraph on the subject of momentum, there are still points connected with it which, having outcomes or results of great practical importance, must be noticed. These are so numerous that they might be explained in a special or single volume, or in a much more elaborate classification than our comparatively brief paper admits of; but we shall pursue the method which we have adopted, of taking the subjects as closely as possible in what may be called the natural sequence—that is, considering some new point as it seems to be connected with or comes out of the consideration of the last treated of. In this way, as it will be perceived that we have just made frequent reference to the effect of falling and moving bodies, as what may be called striking forces, or what in popular language are termed "blows," we shall proceed to explain what we have yet to say on points in which momentum is concerned in a series of paragraphs, the first of which has the title of

Impact.—Blows.—Concussion.

When a falling body comes in contact with the ground—a hammer comes in contact with the body struck, as a nail—or a weight, as the monkey of the piling engine, strikes the head or cap of a pile—in the popular language the ground, the nail or the pile is said to receive a "blow" or to be "struck," and the effect in general terms is described as a "concussion." In technical language the term employed to designate the act of two bodies coming in contact, or rather the effect of a force, is "*impact.*" In pursuance of our usual plan, let us see what notion of these terms, or the conditions rather which they indicate, can be derived from an examination of the meaning or derivation of the words. Take the last named first—"impact." This is derived from two Latin words, *in* and *pactum*, and this from the verb *pangere*, to strike or drive. Impact may therefore be defined as the driving closely together of two bodies, or that condition which arises from one body striking another. When the condition known as impact exists, there is another term frequently used to denote it in relation to two bodies—that is, the word "impinge." Thus, when two bodies are fixed together, or come in contact, the one body is said to "impinge" upon the other. The term is, in effect, but another form of that of impact, and is derived from precisely the same Latin verb, *pangere*, as above named. The one body which is struck receives what is called the "blow," and the result in popular language is, as noted above, said to be a "concussion" between the two bodies. This latter word is derived from the Latin word *concussio*, from *concutere*, *concussum*, and those from the two words *con*, with, *quatere*, to shake. So that the result of a concussion is the act of being (so to say) shaken, the bodies receiving what is both technically and popularly termed a "shock." The term "collision" is used generally to denote the action of two moving bodies coming in contact with each other violently, so that it may be said that the result of the collision was a "concusssion," "shake," or "shock," which broke up the bodies or more or less damaged them.

Collisions.—Shocks.—Blows.—Strokes.

The word "collision" is derived from two Latin words—*con*, with, and *lædere*, to shake. So that a collision, defined as the act of striking together, is the cause, while the concussion is the effect or result. The word "shock," which is the effect of a collision, is derived from the Danish *schok*, the French form being *choc*, a leap, or the shake caused by a "leap," leaping from a high place or distance giving the sensation to which we apply the term "shock."

The word "blow," denoting the effect known as a stroke, which is the result of the act of striking, is derived from the German word *bliggan*, or, as some hold, from the Latin *plega*. The word "strike" itself is derived from the German *streichen*, signifying the touching or holding a body with some force. Other etymologists refer the word to the Anglo-Saxon *striecan*, which of the two seems to us to be the more likely. The word "stroke," which is the result of the act of striking, is derived from the same source or sources above named. Further, when we say that an object is "hit," we mean that it has received a stroke more or less strong from a body thrown or projected against it; and the word itself is derived from the Anglo-Saxon *hettan*, to strike at, or to reach some body at a greater or less distance.

The young reader will, as he proceeds, find that he can learn much from the derivations of terms or words in such frequent use as we here have given, tending to make more quickly clear certain phenomena of moving bodies now to be noticed, and in connection with which much of what has been given in preceding paragraphs must be considered by him.

Impact.—Contact of Moving Bodies.

The effects or phenomena of "impact," arising from the coming in contact of two bodies, may be illustrated by first supposing the bodies to be moving in the same direction, and secondly, to be moving in opposite directions. And here, before giving our examples, it will be well to give the derivation of the word we have now used—"contact," as it is one continually turning up in mechanical description. It is derived from the Latin word *contactus*, and this from *con*, with, and *tangere*, to touch; thus, when the surfaces of two bodies touch each other, they are said to come in "contact" with each other. This contact may be so gently brought about that there is no obvious or perceptible change of condition or position of the two bodies. But the circumstances are very different when one or other of the bodies has, or if both have motion, and that also according as they are moving either in the same way or direction, or in opposite directions. And here it is necessary to state that the phenomena attendant upon cases of impact of moving bodies are more or less influenced by what is called the "condition" of the bodies—that is, the nature and arrangement of their physical constituents, frequently spoken of as their "mechanical condition." This involves considerations connected with "hardness" and "elasticity," both of which properties of bodies will be described in future paragraphs. Meanwhile we assume that bodies are either absolutely elastic or non-elastic—which is, however, only an assumption here, and which in practice must be guarded against by the machinist, as there are in reality no bodies free from elasticity—that is, absolutely non-elastic, on the other hand none absolutely or perfectly elastic. If two bodies, both of them free from elasticity, move on in the same direction but at different rates of speed or velocities, and one of the bodies overtakes the other—or, as we should say, impinges upon it or comes in contact with it—the force or momentum and the velocity of both or of the two bodies is the sum or amount of the force in each. If one of the bodies be larger than the other or of greater "mass," and it comes in contact with the smaller body in a line coincident with that joining their centres, the large body, which, possessing the greater momentum, is distinguished as the stronger, loses a portion of its momentum, while that of the smaller and weaker body, disappearing, receives a portion of the force of the larger body, and both move with a reduced velocity or lower speed. Where a large body is at rest, and is impinged upon by a smaller body which is in motion, the motion will be given to the larger body, but both move on with a reduced velocity or a lessened speed. Thus, if we suppose that a ball weighing 2 lb., and moving with a speed of 20 ft. to the second, comes in contact with or impinges upon another ball, which is at rest, and which weighs 500 lb., the velocity with which the two balls will then move on will be found by multiplying the speed of the small ball by its velocity, which will give the divisor by which the sum of the mass or weight of the larger ball *plus* unity is to be divided: thus $500 \div 20 = 25$. When a ball of a hard and elastic substance, as ivory, strikes another ball of the same material with a given velocity, both balls being of equal size, the first or striking ball comes to a standstill, while the second or struck ball, or that which was at rest, moves or darts on with the same velocity or speed as the first or striking ball possessed. If there be a number of elastic balls, all of which are in contact with each other, all the centres lying in the same line and all the balls of equal mass,—and a ball of the same material and mass be propelled or drives up in the same line as the line of centres of the balls at rest, and acting as the striking ball, when that comes in contact with or impinges upon the first or nearest or "struck" ball, the last in the row or the farthest receives the motion, and darting off moves away in the same line and at the same speed at which the striking ball moved, while the striking ball itself and all the other balls would remain at rest. These instances are given as exemplifying the phenomena of bodies moving in the same direction, and where impact takes place; but the latter examples of elastic bodies are illustrations of another law, to be noticed in the following paragraph. Where two bodies of the same mass or weight, but moving in opposite directions, come in contact in the lines of their centres, the shock or concussion arising from the collision is not that due to the force or momentum of the bodies, but is represented by the sum of the two; or the shock or effect is doubled. This accounts for the difference between the painful effects resulting from one man who is running quickly coming up against or in collision with a man who is standing still, and those the result of two men coming in contact when both are running at the same speed. Hence the "shock," which the reader, bearing in mind what has been stated in a preceding paragraph, will see is the term used to denote the effect on momentum if impact is doubled; and if the speed of the two men were unequal the shock would be represented by the sum of the two forces. Hence also the shock would be the same to both, if both were running at the rate of four miles an hour, or if, while one was standing still, another man came in contact with him who was running at double the speed or eight miles an hour. This also accounts for the disastrous effect of the collision of two steam-vessels going in opposite directions, but at such slow speeds that one ignorant of the law is surprised that so much damage has been done. But this damage or shock is in reality as the sum of the two speeds; so that the vessels receive individually as much injury as if while the one vessel was at rest the other came up against it at a double speed. Much of what has been said in connection with falling bodies in preceding paragraphs affords examples of the terms used in the paragraphs we have just given.

Repulsion.

We have hitherto considered motion as the production, so to express it, of the force to which has been given the name of "attraction," and which has been considered in relation to various phenomena and its general laws explained, and how it produces the different classes of motion known as "accelerated" and "retarded," and another class of motion that is curvilineal, yet to be noticed in a future paragraph. But it is obvious that if the only force in nature were that of attraction, the result would be that all materials or substances would simply rush towards each other, or be compelled, so to say, to form masses, and those again attracting each other, form still larger masses; so that, were there no other force at work or in existence, the result would be the formation of one solid mass of enormous dimensions, and that none of the phenomena we have explained as dependent upon the very force of attraction itself could be displayed. We know that this condition, which pushed thus far is simply an absurdity, does not exist, and that on the contrary, as we have different bodies of all varieties in mass, from the atom or particle of sand of the smallest possible size up to the huge rock, there must be some other force in nature which brings those conditions into existence. To this force the name of "repulsion" has been given. It is derived from the Latin *repellere*, *repulsum*, and these from the two words *re*, back again, and *pellere*, to drive. And this force is defined as the driving of an object back which approaches or attempts to approach another. The force of repulsion, although it acts in so subtle and unobtrusive a way in what may be called the ordinary or normal or natural condition of bodies as not to be readily taken notice of—is indeed in the great majority of cases not made obvious to the senses—acts nevertheless not merely in a potent way, but in one so almost universal that it seems to act in the case of all bodies. Indeed, if we consider that as all bodies are made up of particles and atoms in a descending scale of minuteness, all the atoms reach a condition of such infinite smallness that the mind can form no idea of them as connected with the ordinary conditions known as size, bulk, or dimension—this force of repulsion must exist in all bodies. If not, there would be no separate individuality, so to say, of the constituents or particles of bodies; for the force of attraction which would then only exist, would, as we have already said, bring or cause the particles to cohere and form masses. So subtle, yet powerful, is this "force of repulsion" in normal or ordinary conditions of bodies, that it may be said with almost, if not quite absolute truth, that there is no such thing as the existence of two bodies in actual positive contact. Thus, amongst his many investigations and experiments, the great Newton found that a ball of glass resting upon a flat surface or plate of the same material was so far indeed from touching it, that even a pressure or force applied to the ball equal to one thousand pounds per square inch could not bring the two into actual contact. How powerful—yet so little evident to the senses is it that without the experiment no one could have imagined its existence—must this force be which could thus, as it were, keep the ball suspended in air under so great a pressure! This force of repulsion, in what may be called its natural condition, exists so universally, that a well-known writer on physics puts it in this way—"that there seems to be a film of repulsion, so to express it, covering the general surfaces of all bodies, and preventing them uniting in absolute contact, even when they appear to the human eye so to do." This property or law of repulsion it is which places the various substances with which man deals in the industrial and constructive arts in those conditions in which it is necessary to employ special means to overcome it. Hence arise all the methods, some of them mechanical, some of them chemical, others a combination of the two, by which bodies naturally disjoined or which have been broken or placed asunder are joined, such as the welding and hammering of iron, the melting and soldering or brazing of metals, the cementing or gluing together of stone, glass or wood, and many other methods of obtaining continuity in mass of bodies known to the artificer and mechanic. To this general law of repulsion so acting there are but very few exceptions; so that contact in the sense of making two or more parts into one cannot be obtained by simply pressing them together.

Heat as a Cause of Repulsion.

It is scarcely necessary to remind the reader of what he has in daily life endless examples of,—that this force of "repulsion" acts with varying intensity in various bodies. Where it acts forcibly, we have the atoms or particles of necessity farther apart than in those bodies in which its power or influence is less exerted. Hence we have different conditions of bodies known as "density," "porosity." Those are purely relative terms: as, for example, no body apparently is absolutely dense—since water can be driven, under enormous pressure, through the solid walls of a globe of gold. This indeed follows from what has been said as to the existence of repulsion in all bodies, tending to prevent actual contact of the constituent particles of a body or mass. For if this contact actually existed in the case of the particles or atoms of the gold, there could obviously be no openings or fissures, so to say, through which the water could be passed, no matter what the pressure put upon it might be. The most powerful, at least the source of repulsion most general, is *heat*. This "subtle something" seems, like electricity—which is in certain conditions also a source of repulsive force —to prevail in all matter, to be present in every substance. But like its opposite force—attraction—we know nothing as to what it is. All that we know in both cases are the phenomena attendant upon the two conditions, circumstances or laws to which, for lack of better terms, we give the name of "heat" as a source of the power of "repulsion," and "gravity" as that of "attraction." And with a knowledge of various phenomena, man finds all he requires in practice, and does not need for this to enter into any subtle and purely metaphysical disquisition to show, or attempt to show—for this is itself at the very best an attempt —what "gravity" or what heat is. This subtle something, of the real nature of which we know nothing, in its normal or natural condition pervades, as we have said, every substance, and is met with everywhere. Its opposite condition, to which we give the name of "cold," is not an absolute but only a relative condition, implying that it is a condition in which there is only a lower degree of heat than that existing in some other condition. Cold considered as the opposite of heat would be the absence of all heat; but we reasonably assume that there is no body in this last condition or state. For, low as is the degree of cold—so to use the expression, for which there is no other form in our language—which man can produce, he could still with more perfect appliances produce a still lower degree of cold, or in other words and more correctly, a greater absence of heat. And, fortunately for the work man has to do, he can with greater ease produce an increase of heat than a decrease of it. This fact is familiar to every one in this country, more so than in many others, with the stores of coal at our command.

Bodies in Relation to the Heat or Temperature to which they are subjected.—Change of Condition dependent upon this.—Practical Examples.

With the increase of heat we increase the force of repulsion, and thus have the power to change naturally the condition of bodies, their atoms or particles being more and more separated as we increase the heat, or, to use the common expression, "raise the temperature." In the case of a metal, for example, we first cause a dilatation or extension of the mass; it becomes gradually softer, and in the condition to which we give the name of "melted" we have the force of attraction which caused the particles to cohere or stick together almost overcome. In the case of a liquid, as water, as we apply heat, or increase its temperature, we so disturb and change the molecules or particles of the liquid that we ultimately convert it into the condition of a gas or air to which we give the name of steam. This influence of heat in increasing the force of repulsion is of use to man in such an infinite variety of ways that to give examples of it a large space would be here occupied with them. Many instances will, in addition to those named above, occur to the reader, and of the practical exemplification of which, in machine making, we shall have occasion hereafter to treat. And the phenomena of heat as directly evidenced in the creation or production of steam as a source of motive power, we shall, from their importance, give a special place to in the series of papers entitled "The Steam Engine User." The reader will, of course, bear in mind that as the increase of heat increases the force of repulsion, the converse or opposite condition holds equally true—namely, that decrease of heat decreases the force of repulsion. Thus, if we take a rod or bar of iron in its normal or natural condition, in which its temperature—that is, its supply of natural heat at the time being—is so low that we say the bar is cold, and apply or rather supply heat to it by one or other of the methods of "heat application" at our command, we increase the power of repulsion, the particles are further separated, and the bar, put under the influence of the property known as "dilatation," increases in bulk; but as the bar or rod is in length much greater than in diameter or breadth, this increases the length of the bar. In practice, for the term "dilatation" that of "expansion" is used. Now, if in the same degree or proportion we decrease the heat or reduce the temperature—which may be done in the readiest way by taking away the "heating application" used—so as to allow the bar to assume or return to the normal temperature at which it before existed, we have the power or force of repulsion lessened; the particles or atoms come closer together, and the bar shortened recovers its regular length. This process or operation is known by the name of "contraction." A useful exemplification of this property of dilating or expanding and contracting of metals, showing its adaptation to mechanical work, is the "shrinking on" of iron bands or straps on parts of machines, etc., the most familiar example of which is the "shrinking on" of the iron tire of a cart-wheel. Another is the loosing of fast bound "nuts" of screw bolts. The nut is grasped by a pair of tongs made red hot; the heat is communicated to the nut in a quicker time, of course, than it is to the screw bolt inside of it; the nut therefore dilates and becomes looser, so as to be moved by the spanner.

THE STEAM ENGINE USER.

THE DIFFERENT CLASSES OF ENGINES USED CHIEFLY FOR MANUFACTURING AND AGRICULTURAL PURPOSES.—THE LEADING DETAILS OF STEAM ENGINES—CONSTRUCTIVE AND OPERATIVE.—THEIR PRACTICAL WORKING AND ECONOMICAL MANAGEMENT.

CHAPTER XIII.

THE following description and accompanying illustration (fig. 22, p. 25), fully explains the working of Newcomen's engine, referred to at end of last chapter.

A piston, P, movable in the steam cylinder A, was attached by a chain to one segmental end of the working beam, the pump-rods, R, being hung by a chain to a similar segmental end at the other end of the beam. The boiler, B, was directly under the cylinder, and a plate or regulator valve, K, admitted the steam to the latter. Towards the bottom of the cylinder was a small pipe terminating in a clack valve, D (called a snifting valve), opening upwards. A pipe, E F, leading to a cistern of water overhead, was fitted with an injection-cock, E. There was also a waste or eduction pipe, L M, terminating in a small cistern, and having at its end a clack valve, M, immersed in water, and opening upwards. A vertical rod, H G, was employed for working the valves; but there is no indication on the drawing as to how the connection between the valves and this rod was made. A small pump, T, was used to raise water into the cistern above the pipe E F.

The weight of the pump-rods was greater than that of the piston, and acted as a counterpoise to keep it at the top of the cylinder, unless brought down by external pressure. In order to work the engine, the pressure of the steam in the boiler should be at least 1 lb. per square inch in excess of that of the atmosphere; and the reservoir should be several feet above the bottom of the cylinder, whereby a strong jet of injection water would be thrown in. The piston being, as above stated, at the top of the cylinder, the steam regulator K was opened, and the entering steam cleared out all air from the space A, and drove it through the valve D. The injection-cock, E, was then opened, whereby the injection water entered the cylinder, slowly at first, but with great force afterwards, as the condensation went on and the pressure of the enclosed vapour was reduced to one-half or one-third of that of the air outside. The injection-cock was provided with a weight, to insure its opening quickly. The condensation of the steam took away the pressure from the lower surface of the piston, and there being nothing to balance the pressure of the atmosphere on its upper surface, the piston descended and lifted the pump-rods, together with the column of water resting upon the buckets. In this way the downstroke of the piston was effected. The ascent of the piston in making the return stroke was effected by closing the injection-cock E and opening the regulator valve K, so as to admit a fresh supply of steam. The waste injection water at the bottom of the cylinder would cause some loss of the entering steam, but it would soon be expelled through the eduction pipe. The pressure on the lower surface of the piston would be at first a little greater, and afterwards about equal to that of the atmosphere, and hence the weight of the pump-rods would carry the piston to the top of the cylinder. The injection-cock would then be opened, and the action would go on as before.

Watt's Experiments.—The next important improvement in the steam engine was the invention of James Watt, who, in 1765, whilst employed to repair a model of a Newcomen engine, made the discovery of a separate condenser which has identified and made famous his name in connection with the steam engine. Watt says: "I set about repairing the engine as a mere mechanician, and when that was done and it was set to work, I was surprised to find that the boiler could not supply it with steam, though apparently quite large enough—the cylinder of the model being two inches in diameter and six inches stroke, and the boiler about nine inches in diameter."

He considered that the waste of steam was due to the fact that the small cylinder of the model exposed a greater surface for condensation in proportion to its contents than would be found in the cylinder of a full-sized engine. He also thought that "the cylinder of the model, being of brass, would conduct heat much better than the cast-iron cylinders of large engines, and that considerable advantage could be gained by making the cylinders of some substance that would receive and give out heat slowly."

He tried a cylinder made of wood which he had previously soaked thoroughly in oil and baked to dryness; but it soon became apparent that the material was unsuitable, and the proportion of steam condensed on admission into the cylinder still exceeded that in large engines. He also found that any attempt to produce a better exhaustion of steam by increasing the quantity of injection water only produced a greater waste of steam. Several experiments were conducted by Watt from which he concluded that "in order to make the best use of steam, it was necessary first that the cylinder should be maintained always as hot as the steam which entered it; and, secondly, that when the steam was condensed, the water of which it was composed, and the injection itself, should be cooled down to 100° F., or lower where that was possible. The means of accomplishing these points did not immediately present themselves; but early in 1765 it occurred to me that if a communication were opened between a cylinder containing steam and another vessel which was exhausted of air and other fluids, the steam, as an elastic fluid, would immediately rush into the empty vessel, and continue so to do until it had established an equilibrium; and that if that vessel were kept very cool, by an injection or otherwise, more steam would continue to enter until the whole was condensed." He then thought the desired end would be obtained by employing a pump which would extract both the air and the water from this second vessel, which formed the separate condenser of the improved steam engine.

Watt also introduced the use of tallow or other grease as a lubrication for the piston, and which also had the effect of making a tighter joint between the piston and cylinder than had the former method of using water packing. He likewise added a cover to the upper end of the cylinder, with a hole through which the piston-rod passed, made steam-tight by a stuffing box; by the use of which steam might be admitted above the piston, to act on it instead of the atmosphere. The cooling of the cylinder he proposed to prevent by the use of an outer casing filled with steam, which in its turn was protected from the cooling effect of the atmosphere by a coating of wood or other non-conducting substance. This last improvement will be readily recognised as the "steam jacket" of the present day.

A few extracts from the specification of the patent granted to Watt in 1769 for his invention of the separate condenser may be of interest. He describes his invention as "a new invented method of lessening the consumption of steam and fuel in fire engines." He says, in describing the "principles" of his invention:—

"*First.* That vessel in which the powers of steam are to be employed to work the engine, which is called the cylinder in common fire engines, and which I call the steam vessel, must, during the whole time the engine is at work, be kept hot as the steam which enters it,—

"1. By enclosing it in a case of wood or other materials that transmit heat slowly;

"2. By surrounding it with steam or other heated bodies;

"3. By suffering neither water nor any other substance colder than steam to enter or touch it during that time.

"*Secondly.* In those engines that are to be worked wholly or partially by condensation of steam, the steam is to be condensed in vessels distinct from the cylinders, though occasionally communicating with them. These vessels I call *condensers*, and whilst the engines are working they ought to be kept as cool as the air in the neighbourhood by the application of water or other cold bodies.

"*Thirdly.* Whatever air or other elastic vapour is not condensed by the cold of the condenser is to be drawn out of the steam vessels or condensers by means of pumps wrought by the engines themselves or otherwise."

With reference to other improvements in the steam engine effected by Watt, the same specification says: "Instead of using water to render the piston or other parts of the engines air- and steam-tight, I employ oils, wax, resinous bodies, fat of animals, quicksilver or other metals in their fluid state."

Fig. 23 is an illustration of one of the early forms of pumping engines, with a steam-jacketed cylinder and a separate condenser as proposed by Watt. A steam pipe, S, opening into the jacket surrounding the steam cylinder A, is so arranged that a supply of steam shall always act upon the upper surface of the piston,

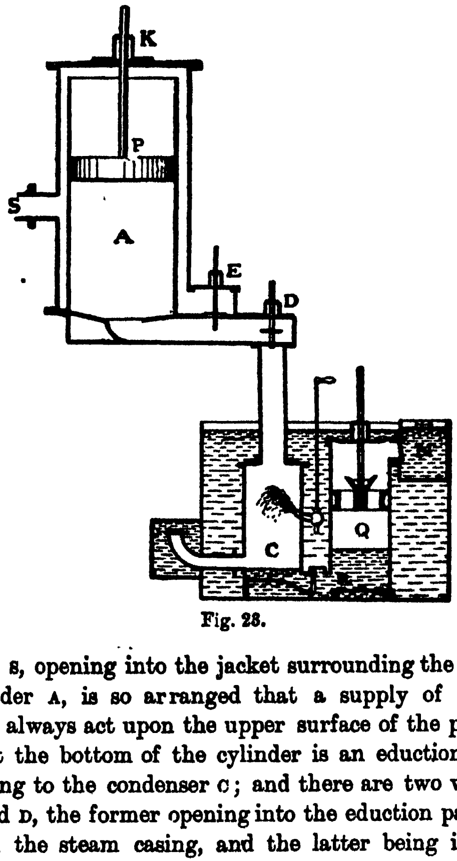


Fig. 23.

At the bottom of the cylinder is an eduction pipe leading to the condenser C; and there are two valves, E and D, the former opening into the eduction passage from the steam casing, and the latter being in the pipe itself. An injection orifice admits cold water into the condenser. An air-pump, Q, removes the water and air which are continually accumulating in the condenser, whilst a foot-valve, B, prevents any return of water or air to the condenser. At the top of the air pump there is a delivery valve, N, opening into a reservoir which is there to receive the water from the condenser. As this water becomes warm by condensation of the steam, it is used to supply the boiler, a saving in fuel being thereby effected.

So early as 1776, Watt made experiments on the expansion of steam, and about the same time he altered an engine to test the result of an early cut-off.

After many experiments, in 1782 Watt took out a patent for "certain new improvements upon steam or fire engines for raising water or other mechanical purposes." He says, in the specification, "My first new improvement in steam or fire engines consists in admitting steam into the cylinders or steam vessels of the engine only during some part or portion of the descent or ascent of the piston of the said cylinder, and using the elastic forces wherewith the said steam expands itself in proceeding to occupy larger spaces as the acting powers on the piston through the other parts or portions of the length of the stroke of the said piston." Expressed in other words, the steam valve remains open only during a portion of the stroke of the piston, and closed whilst the stroke is completed. Or it may be expressed as follows: The steam from the boiler is admitted to the cylinder during only a part of the stroke; this admission being stopped, the steam in the cylinder has then to complete the remainder of the stroke by its expansive property. The following example will help to explain what is meant by the expansive property of steam. Suppose we have a cylinder full of steam at a pressure of 30 lb. per square inch, and we compress this into a space equal to one-half of the area, the pressure will then be double what it was at first—viz., 60 lb. per square inch. If, on the other hand, we allow it to fill a cylinder of double the cubical contents of the original one, the pressure of steam will fall to 15 lb. per square inch: *i.e.*, compress the steam into half the original area, its pressure is doubled; allow it to expand to double its original area, and the pressure becomes only one-half of what it was at first. The law relating to this fact is commonly known as Boyle's, otherwise, and perhaps better, as Marriott's law, and is expressed thus:—The pressure of steam varies inversely as the space it occupies.

Hitherto the engines described have belonged to the class known as *single-acting* engines—that is, the steam acted only on one side of the piston, relying on the pressure of the atmosphere for the return stroke. When steam drives the piston both up and down, the engine is termed *double-acting*. Nearly all modern engines are of this latter class, there being a few exceptions. Newcomen's engine was atmospheric and single-acting, the piston being driven *up* by steam, but *down* by atmospheric pressure.

Watt's first engine was single-acting; the steam drove the piston *down*, whilst the weight of the rods, etc., at the other end of the beam acted as a means of raising the piston *up*.

In constructing an engine the cylinder is made a trifle longer than the actual travel of the piston. This prevents any knocking of the piston against the ends of the cylinder, and at the same time allows a space for the free entrance of steam into the cylinder at the beginning of each stroke. Such a space is called the *clearance*.

It is an advantage, too, to imprison the steam in the cylinder in such a way as to act as a *cushion*. This has the effect of bringing the piston gradually, so to speak, to rest. As an example, suppose the piston is in the position indicated in the accompanying type diagram, fig. 24, when the steam is shut off, and that the distance from A to B is twelve inches. We will assume that the elastic force of the steam in the space A B C D is equal to 2 lb. per square inch. When the piston has travelled six inches farther down, the elastic force will be increased to 6 lb. per square inch according to the law we have just now quoted. When the piston has travelled still farther, say nine inches down, the pressure will have become 8 lb. per square inch; and so on to the end of the stroke, when the piston will have been brought gradually to rest, and ready for a fresh influx of steam from the boiler to drive it upwards, when the same action is repeated in the upper side of the piston.

Fig. 24.

It may be well here, now that we have traced some of the more important improvements in the steam engine, to describe and compare some of the principal parts of the beam engine of Watt's time with corresponding parts of engines of to-day. Perhaps the most fitting to begin with will be the *Beam* itself. So important was the beam in a steam engine considered in the days of Watt that it was some time ere practical men could be induced to discard it.

An early form of beam is preserved in the museum at South Kensington, and is illustrated in fig. 25.

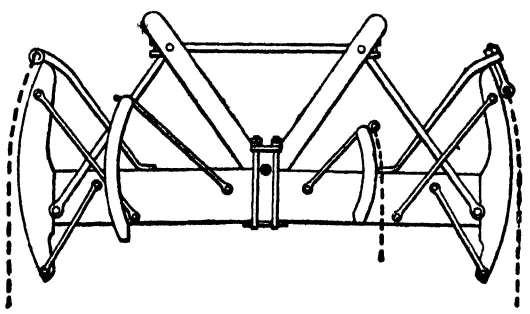


Fig. 25

Another form is that used on the engine known as the Soho engine, also preserved in the Museum amongst the inventions of Watt.

There also stands in the same building another interesting engine known as the Heslop engine, to which we refer our readers, for which a patent was granted in the year 1790. This engine was described in [illegible] paper read before the Institution of Mechanical Engineers a short time since.

THE FACTORY OR MILL HAND AS A TECHNICAL WORKER.

THE ORGANISATION, GENERAL DUTIES, AND SPECIAL WORK OF THE STAFF OF FACTORIES FOR THE PRODUCTION OF SPUN AND WOVEN GOODS—THAT IS, "YARN" AND "CLOTH"—AND THOSE CHIEFLY IN COTTON AND WOOL—GENERAL DESCRIPTION OF THE VARIOUS PROCESSES OF MANUFACTURE.

CHAPTER IX.

REFERRING to the illustration in fig. 7, p. 2, we, in continuation of its description, have to note that whilst the covers remain open, the one-armed lever *k* is moved by the grooved disc *h* catching in the pin *j*. At the end of *k* is the cleaning board, which moves to the left and back again, removing the waste cotton and dirt from the raised cover. In order to change the order of lifting the covers, Rieter's machine has at each side of the toothed rims two segments of unequal length. The continual cleaning of the drum is caused by a doffer placed underneath, and deposits the dirt on a roller. The roller throws the dirt on to the drum, and the drum on to the lids.

Having thus generally described and illustrated the carding process, and the machine by which it is done, we proceed to give some practical remarks as to the work as carried on in the mill, and the general management of its details.

The General Management of the Card Room.—Details of the Carding Engine.

The carding engine is composed of the following parts, which constitute the active operators on the cotton. The main cylinder—why it is called the main cylinder is obvious from the fact that from this cylinder not only the other cylinders (which go under different names), but all other moving parts, receive their motion directly or indirectly—a smaller cylinder, called a doffer, and also another still smaller cylinder (in diameter), the taker-in,—these three are used in all carding engines, and not one could be dispensed with without a serious loss. The main cylinder, where coarse yarn is produced, is covered to the extent of nearly one-half of it by small cylinders, commonly called "rollers and clearers." Main cylinder, taker-in, rollers and clearers, and the doffer, constitute the whole of the machinery in the carding engine for the treatment which the cotton requires to be put through, so that it may be sufficiently prepared for the following machine (drawing frame), hereafter to be described. Very few cylinders, of either a large or small diameter, which have been made within the last half-century, are made of wood, as they were formerly, since it has been found that cast-iron cylinders can be made very light, and in every other way convenient for affixing the clothing and securing it as firmly as in the case of the old cylinder, which was composed of wood. The preference for using iron as cylinders instead of wood for the purpose, arose from the fact that iron is almost free from the action of the different atmospheres. The bottom room—ground floor—is invariably made choice of for the card room, and this being flagged is usually more or less damp. There are advantages in the use of the ground floor for the card room; but we have, of course, to meet any disadvantage which might accrue from it. Wood, wherever it may be situated, or in whatever position or form it may be, is liable to warp, *i.e.* to be drawn into different forms; and, as we know from experience, in any kind of goods which require to be kept in truth, wood cannot be depended upon to keep in its original position. Nothing can be as important, for truth and for certainty of action, as the cylinder or cylinders in a carding engine, and hence the use of some other material which is less liable to be affected by changes or circumstances of weather than wood. In this case the substitute for wood is an article which is becoming almost universally applied to any kind of work where strength is required, neatness desired, or for its property of resisting circumstances to which wood is so much subject—*i.e.* iron. It is almost incredible how light the cylinders for this purpose are made, and at the same time substantial. The first cost is a little more, made from iron, than from wood—say 10 to 15 per cent. Though there is an advantage in some directions, and certainly in the most important object of using it, there are drawbacks to it, but they are not deemed of sufficient import to return to the old system of wooden cylinders. Here we may state them, as we have so far referred to them. The difference between the weight of wood and iron is that, however light the iron is made, it is more cumbersome to be moved about than wood, bulk for bulk, and therefore more power is required from the steam engine, which, though small, adds to the cost of fuel and wear-and-tear; besides, the power required for turning the carding engine is greater, and more manual labour in removing parts for the sake of cleaning and repairing is required. But, as we have before said, continued truth more than compensates for the small additional cost. As to the framework, remarks are not needed, as in this case—it is also so in all other cases—the framework is made so as to be suitable for the various parts of cylinders, etc. The real working parts of the machine, where the cotton has to be carded, are covered with a clothing. For the foundation of that clothing different kinds of cloth are used (all made for that purpose), which is filled with hooked teeth, very closely set, say from 60 to 150 teeth to the inch; and the fineness or coarseness is regulated according to situation, etc. The taker-in rollers and clearers have the coarsest-set wire, varying from 60 to 90 teeth per inch. The next finer-set clothing is used on the main cylinder, from 100 to 120 set. The doffer has, as a rule, the finest-set clothing that is on a carding engine. It varies from 110 to 150 set. It will be well understood why the doffer is so much finer than any other part.

Details of the Carding Process continued—The Lap Machine.

We have given an idea of the various parts which are in contact with the cotton while it is being passed through this machine. The first thing which is to be understood is the lap, which is made at the lap machine. This lap will be perhaps eighteen inches in diameter. Being folded upon a roller, pressed by calender rollers which consolidate it, at the lap machine, and the lap machine roller being extracted from it as it is filled, a small rod can be put in in the place of the lap roller. The back part of the carding engine is arranged with two plates, one on each side, provided with a slot, by which the rod in the lap can be kept in its place, and thus the lap is so far secured from getting out of the position, during the time which it may have to remain in the blowing room, which it is necessary for it to be kept in. The lap rests upon a roller which is turned round by tooth and pinion, and thus it unfolds the lap from the layers as it received them from the lap machine. As the lap is unfolded it is taken hold of by two rollers, and sometimes with one roller running in a dish; either system carries out the object of drawing the cotton through. These rollers are so calculated that they run through the same surface per minute as that of the roller which turns the lap round, and so the lap is neither stretched nor allowed to overrun. The rollers alluded to are called feed rollers; they draw the cotton through, and deliver it to the first cylinder or roller, which is used for the working, clearing, and preparing of the cotton. This roller goes by the name of taker-in, or licker-in. Its diameter is about nine inches, and its surface speed is about equal to half of that of the main cylinder. This taker-in is clothed mostly with the coarsest kind of clothing. The cotton, as it leaves the lap machine, must of necessity be in a very rough condition, and hence the need of stronger wire clothing.

Practical Points connected with the Management of the Carding Process.

The cotton, as it leaves the lap, is in a rather lumpy and uneven condition. The feed rollers running but very slowly, and the lap, or feeder, being rather bulky, the taker-in takes off the cotton as it comes through them in very small particles. The cotton, of course, gets more distributed (separated); and before describing the further process, perhaps it would be as well to state that this taker-in, by running at a high speed comparatively to that of the feed rollers, takes but little at each stroke, or we may say at each revolution, and thus the dust or heavy dirt which remains in the cotton is largely disposed of; and, in addition to the dust, it will be seen upon examination that some other material falls out of the cotton which would be useless. There are some of the fibres which are very short, others which are of a coarse nature, and it will be thus seen that all cannot be perfect. The "taker-in" does some important work, and it does the roughest part of the work which is required to be done after the cotton leaves the blowing room. The object of the taker-in is twofold: first, taking the cotton from the feed-rollers and passing it to the main cylinder in small particles; and secondly, freeing the cotton from much superfluous matter, dust, and short fibres. The sooner the dust and other useless substances are disposed of, the better. The licker-in, or taker-in, is a real boon to the other part of the working of the carding engine. As we have said, the sooner all useless matter is disposed of the better, because it much interferes with the f set wire which has to be put upon the other part of carding engine. Dust and other coarse material t away the fine edge of the wire which is upon the clothing on the main cylinder. The object of having the rollers and clearers upon carding engines is to distribute the thick and lumpy parts which are put upon the cylinder by the taker-in. The roller and clearers vary in diameter; but, for argument will say that the roller is about seven inches and the clearer is say four inches diameter. roller being set close to the cylinder, it will not large pieces to pass it, and so it takes them off part. Its speed is but very slow, so it allows the cylinder to take part of the lump back again, after all that the roller brings up. The clearer is set so close to the roller that nothing can pass it unless it is very small. The clearer receives its name from the part of the work it does—*i.e.* it clears the roller from all that it takes up from the cylinder. It runs at a high speed, and thus the fibres are taken back to the main cylinder in a thinner and more suitable state for the next set of rollers. There are a series of those we have described of rollers and clearers, all of which perform the same kind of work, that of separating the bunches of fibres as they arise, and equally distributing them. Being so well apportioned all across the cylinder that as it is taken off the last cylinder, called a doffer, it is regular, and as free from thick and thin places as a spider's web, it is thus frequently called the web. When all the parts of the engine have done their work, the doffer is then the part which takes from the cylinder the carded cotton. The main cylinder makes from 120 to 180 revolutions per minute, and is about 45 inches in diameter; the doffer is half the diameter of the main cylinder, and its revolutions about 1 to 14 of the cylinder. The opposite side of that to which it is in contact with the cylinder, there the cotton is stripped, or doffed, from the doffer by a comb or knife.

THE STEEL MAKER.

THE DETAILS OF HIS WORK—THE PRINCIPLES OF ITS PROCESSES—THE QUALITIES AND CHARACTERISTICS OF ITS PRODUCTS.

CHAPTER IV.

Brief Description of the Early Methods of Making Steel.

It is not always easy to classify several processes which, having some points in common, overlap each other, so to say, and which taken as a whole, however numerous—and the processes of steel making are many—have but two or three leading principles, of which the several processes are but modifications. We propose, however, to consider all that is necessary under two classes—the "direct" and the "indirect," or, as we may call them, the "roundabout" processes. To these some would, and do, add a third; but it in reality belongs to the second. By the "direct process" we refer to the method or principle of steel making which deals with the ores, making the steel at once from these, without the intervention of preliminary processes. It is this which creates the difference between this class and that we have designated as the "indirect process," which deals with products made from the ore, as primarily in the form of cast or "pig-iron," or in that of malleable or "wrought iron," which again is a secondary product of the ore, being itself derived from the pig-iron first produced from it. We have, in the chapters entitled "The Iron Maker," drawn attention to the comparatively late discovery of the fusibility of iron ore so completely that it could be run in a condition more or less fluid into moulds, from which the name *cast*-iron was obviously derivable—hence a more correct term than pig-iron, which had its origin in the vulgarisation of a fanciful idea of the early workmen. From this it will be evident that the direct process of steel making must have preceded any of the modern methods, whether direct or indirect; inasmuch as the manufactures of both steel and iron claim an antiquity far exceeding that of the manufacture of modern cast iron in this country. An antiquity, indeed, so great, that reaching far into the ages "hoary grey with eld," we have not the faintest record of the times when either iron or steel was first produced; although, as we have just seen, we have data upon which to found a conception of what the earliest processes must have been—this abundantly proved by processes carried on even still in some remote districts, and of which we have historical proof that in comparatively recent times they were universally used by peoples of the East.

Early Steel Making in the East.—"Wootz" Steel.

Of these early processes we have already described, and which may be taken as representative of the whole, properly defined there was but one process, modified merely in the details of working; the one plan we have described constituting the variations which caused the difference in the products obtained. We shall now take up those methods of treating iron ore which gave definite results in the form of steel—that metal which has been so long and universally distinguished as being different from the metal known as iron by the fact that it is capable of being hardened and tempered so as to be brought to, and maintain under fair usage, a cutting edge. And to give an idea of how this definite product was obtained in early times, we go again to the East, to find the making of steel illustrated in that quality of it known as "Wootz," from the name of a certain district in India, and which was capable of giving to implements made from it cutting edges of the finest and keenest. A parallel product, so far as fineness of quality was concerned, was the still better known metal known as "Damascus" steel; this Syrian manufacture having the widest and highest fame for the exquisite keenness of the cutting edges of swords made from it. Wootz steel could scarcely come under the class of direct processes, it being made from the iron obtained by the process we have described in a preceding paragraph. That this iron was of the finest quality we have already seen, approaching that of the modern ingot or soft steels; and we have also seen that in some particular instances it might have been steel proper or hard. This fine quality of iron thus produced was, in the process of Wootz steel making, taken and broken up into small pieces, and what appeared to the practised eye of the natives to be the best pieces were selected. These were placed in clay crucibles, and packed therein carefully, along with small pieces of wood. A number of the crucibles thus filled with selected iron and wood were placed together in a furnace—some two dozen or so at a time—and then covered thickly over with green leaves of trees, and these with a layer or covering of clay. The blast—obtained by a primitive form of bellows, worked in as primitive a fashion—was then applied, and the combustion maintained in the furnace at as high a heat as possible for some two hours and a half. The furnace was then allowed to cool down, and the crucibles were removed, broken up, and the pieces of metal taken out—forming lumps of the well-known "Wootz steel."

Early Steel Making in Europe.—The "Catalan" Process.

In Europe the production of iron proceeded much on the same lines we have described as constituting those of the earliest times in the East. Of the European peoples, those of the north took a high place as iron workers: in Germany, for example, the position of the trade was such that the technical terms employed in it have been brought into our country, either almost in their pure form, or have given the basis of terms made by us to indicate the same thing. The Swedish iron has, for example, long held the reputation of being the finest in Europe, and is that used chiefly for the making of steel on the Sheffield plan, as to be afterwards described. Of the European processes, that known as the "Catalan" is a good example of making steel direct from the iron ore. The furnace has its hearth or bottom of a rounded form, made of a species of sandstone very "refractory"—that is, capable of resisting intense heat. The blast of air is produced in a peculiar way by a falling column of water supplied from a cistern, tank, or reservoir, placed at a considerable elevation above the level of the hearth of furnace. As the water descends the vertical tube leading from it, it carries with it air, which is allowed entrance to the tube near its upper end; and by a simple arrangement, while the water passes freely away to a lower level, the air is forced at considerable pressure through an inclined and tapering tube to the hearth of the furnace, maintaining a steady combustion at a high temperature. The ore used in the process of steel making by this primitively simple, yet in some districts of Europe, as in the Pyrenees, still used form of furnace, is rich in metallic iron. Springing from and leading up from the hearth is a wall made with a curved upper part joining the vertical side of the furnace, this being placed in the side of the furnace opposite to that at which the tongue or blast pipe is placed. On this wall the iron ore is piled or heaped up, and is at first prevented from falling down to the lower part of the hearth by the "charge" of fuel which rests upon the hearth and fills the lower part of the furnace up to the level where the curved part begins. The fuel used, it is scarcely necessary to state, is charcoal; this fills the furnace or hearth part up to a considerable height; and the mass of charcoal is then covered over with a thick layer of a mixture of charcoal dust and iron ore broken in small pieces. When this mixture is wetted or moistened, it forms a species of closely lying covering. At first commencing the process, a gentle heat is maintained in the mass of burning charcoal lying on and in the region of the hearth. When combustion has reached that point where it forces its way through the mixture covering the charcoal, more of the mixture is heaped on, so that combustion is kept low. After this low combustion has been maintained for the space of two hours or so, the blast of air is turned on, so that it exercises its full power, and fierce combustion goes on in the mass of charcoal and its covering mixture. The ore is then dragged gradually from the curved and sloping back of the furnace, in which, as we have seen, it is piled up; and as it is subjected to the intense heat, it is partially smelted. This goes on till the whole of the charge of ore is "reduced" to a mass of what is technically called "spongy iron." If this were allowed to remain in the furnace it would be still further reduced till it was fused or melted; and as it reached this point it would be found to have absorbed certain greatly deteriorating impurities, making it a metal in its characteristics totally distinct from that known as steel or hard steel. But when the ore is reduced to the spongy condition, it is withdrawn from the furnace, and then hammered and rolled or drawn out. This primitive process, which, as we have seen, is still used to a limited extent in some European districts, is the basis of a steel-making process carried out on a large, and, as we believe, on a commercially successful scale, in the United States of America, in which wood for charcoal making is very plentiful. It is there called the American bloomery, and it need scarcely be said that the furnaces and appliances are arranged and constructed on a vastly different and greatly improved plan as compared with the rude appliances of the Catalan process above described. The furnaces of the American bloomery are thus elaborate structures, and the blast is on what is called the "hot blast" system (see the chapter under the head of "The Iron Maker"). The name "bloomery" is derived from the word "bloom," which in the technical language of the iron trade is used to designate a ball or mass of spongy iron as it is withdrawn from the furnace to be hammered and rolled.

Steel Making direct from the Iron Ore.

It is scarcely necessary to say that, apart altogether from the fact that the early iron workers obtained their supplies of steel largely, indeed—so far as we can conjecture, from the evidence we have at command—chiefly from direct processes, such as the "Catalan," now described, there are obviously clear reasons why the iron masters or steel makers of our own times should have had, and still have, a desire to find some method of obtaining steel directly from the iron ores without the intervention of intermediate processes—hereafter to be described—which if they do not add to the cost, certainly add materially to the labour of producing steel. Hence in comparatively recent times various attempts have been made to discover a method of making steel directly from the ores as they are taken from the ironstone mines. And seeing the value of the prize to be secured by those who succeeded in making the direct process a success, attempts are being made even now, and some of these are in the hands of men of such distinguished scientific ability and thorough practical knowledge, that the world may shortly have it announced that the problem has been solved. This is not to discover a method of making steel directly from the ores: that was solved long long ago by the primitive or early iron workers, and steel can be made—is in various parts of the world being daily made—directly; but the solution of the problem is in making the direct process a paying one.

THE CARPENTER AND HIS TECHNICAL WORK.

ITS ORIGIN AND EARLY PROGRESS—THE PRINCIPLES AND DETAILS OF ITS PRACTICE.

CHAPTER X.

Joining of a Horizontal with a Vertical Piece.

IN fig. 5, Plate XIX., we illustrate a joint in which a horizontal piece, *b*, is secured to the face of a vertical strut *a a* in the manner shown at *d e f g*; *d* shows the piece cut out in the strut *a a*. This may be cut right across the face of *a a*, but if so there is nothing to prevent the piece *b* from being pushed laterally out of connection with *a a*. To prevent this a rib is left in the centre of the part cut out of face *a a* at *d*. This rib goes into a groove cut out of the end of the piece *b*. In place of a rib being left in the face of the part cut out at *d*, the mortise hole, as *g*, is made; into this a tenon left at end of piece *b*, as shown at *h*, is driven Other views of the piece *h* are shown at *k k l* and

Another Method of Joining a Horizontal with a Vertical Piece.

In fig. 47 is illustrated a method of joining a horizontal piece, *g h*, to a vertical piece, *h*. The front view of vertical piece is shown at *a b*; a groove, *c*, is cut across this, in which the part *h* of horizontal piece *g* is placed. A part, as at *j k*, may be cut across the face of vertical piece, the end of horizontal piece being formed to suit this; or the joint shown at *r r q* may be used. In this the face of the vertical piece is broader than the thickness of the horizontal, a mortise being cut in the face of it, as at *p p*, and this provided with a second mortise, *o*, into which the tenon, *q*, of horizontal piece fits, the end going into *p p*. The ends or inner faces of *p p* and *o* are not parallel to the sides of the vertical piece, but oblique, as shown in vertical section at *l m* or *n*. Fig. 8, p. 12, vol. i. (*ante*), shows another method of joining a horizontal piece, *a a*, as at *e*; or a square tenon may be used, as indicated by the dotted lines joining *e* in *d d* with *e* in *b.b*. *f g* shows edge view of piece *a a*, *g* being the tenon *e* in *b b*. Where the dovetail tenon is used, as at *e*, the mortise, in place of being plain, as at *h*, may have two shoulders, as at *k k*, against which the parts *j j* abut.

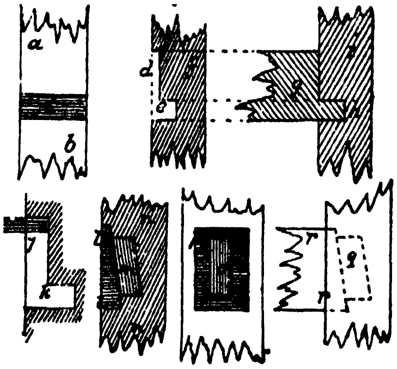


Fig 47.

Joining Two Horizontal Pieces, one of which—a Ceiling Joist—is at Right Angles to the other, as a Bridging Joist, in Flooring.

In fig. 48 we illustrate the methods of joining pieces at right angles, as the "ceiling joists," *e f*, to the "bridging joists" of a floor, as *b b* (see a succeeding chapter on Floors). The simplest method is by cutting a notch, as *a*, in the lower edge of the bridging joist *b b*, this going right across the face, as shown in plan to the left of *b b*. The notch is cut of such a width that it embraces the ceiling joists tightly when this is driven up. The joist is indicated by the dotted lines. Other methods are shown at *c* and *d* of finishing the ends of the ceiling joists *e* and *f*; notches, as *c*, being cut in the bridging joists to receive the tongue of projecting parts at *c* and *d*.

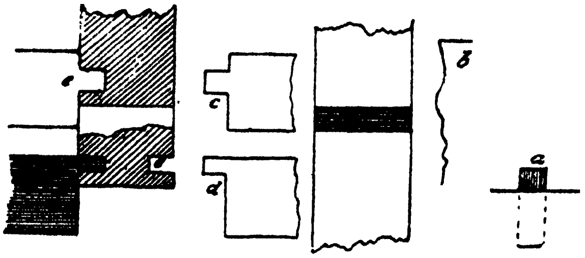


Fig. 48.

Junction of One Horizontal Piece, as in a Bridging Joist, to the Vertical or Another Horizontal Piece, as a Beam or Girder in Flooring.

The junction of pieces at right angles, where the end of one piece is secured to the vertical face of the other piece, as *b* and *f* in last figure, is illustrated in the junction of bridging joists, *a*, fig. 49, with the large beam or girder *b* in a double-framed floor (see succeeding chapter on Floors). The face of the girder has parts cut out at intervals corresponding to the distances between the bridging joists, as at *g*, the end of joists *a a* being shaped to correspond. The width of the part cut out in face of the girders is equal to the thickness of the joists *a a*, as shown at *e* in face *d* of the girder. In the figure *e* is end or cross section of a flooring joist, the ceiling joists being placed immediately below it. In some cases the end of the joist is cut so as to finish with a long

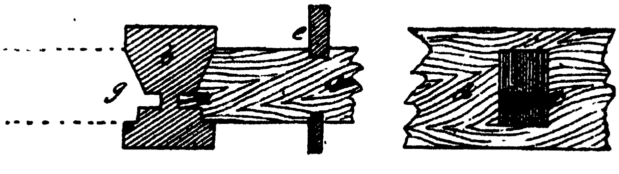


Fig. 49.

projecting piece, tenon or tail; this passes through a mortise hole in the girder at back, and the two are secured together by a wedge, as shown in fig. 50. When the junction is made as in fig. 49, the end of joist being merely let into the face of the girder, the joist is not so secure as that shown in fig. 50.

Junction of a Horizontal Piece, with an Inclined or Angular Piece.

In fig. 6, Plate VII., a joint is illustrated in which one piece, as *a a*, crosses horizontally an inclined piece, as *b b*. The simplest way of making this joint is cutting out a recessed portion, or a chase, as *d*, in the outer face of piece *b b*. The depth of this being half the thickness of the piece *a a*, when this is forced into the part *d* half the thickness of *a a* projects above the face of *b b*. When the two faces, that of *a a* and that of *b b*, are required to be flush with each other, a part of shape corresponding to the angle *d* is cut also out of the (inner) face of *a a*, half the thickness of the piece in depth. This is shown in elevation at *c* and in section at *f*. The most perfect and secure of this kind is where the part, as *d*, is not cut out right across the face of piece, as *b b*, but a rib, feather, or projecting part *h*, as at *g g*, is left in the centre. This fits into a recess or hollow part in the inner face of piece *a a*, so that lateral movement is prevented.

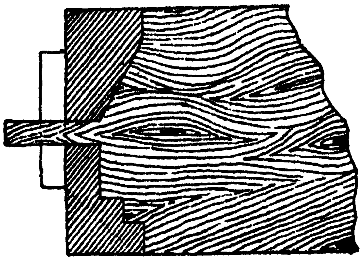


Fig. 50.

Another Example of Preceding Joint.

Fig. 8 (*ante*, p. 12, vol i.) illustrates a joint of the same class as the last, in which one piece, as *i i*, crosses another, *k k*, at an angle, but in which the joint is not straight-lined, as at *a a*, *b b*, fig. 6, Plate VII., but is cut out with angular knees, as shown at *i i*. Another form of angular joint of this class is shown at *g h*, crossing the piece *f*, the shaded part *g* showing the recess or mortised part cut out in face of *f*. The diagram at top of this, fig. 8 (*ante*), shows a form of joint in which the piece *c* joins the piece *d d* at an angle; but does not extend or go beyond the furthest or off side, as at *i i* in same figure. The part cut out of piece *a a* corresponding to *d d* is shown at *b*, with edge view at *c*.

Junction of Two Pieces Crossing Angularly.

Fig. 51 illustrates another class of joint, in which two pieces, *a a*, *b b*, cross each other, both pieces being placed angularly: *c c* shows the face of one piece, as *b b*, with part cut out to receive *a a*. One form of the joint is shown in section, *d e f* being a recess cut out of part, *g* being a correspondingly projecting part left in the centre of the other piece. The usual and the simplest way is to make the same kind of recessed or cut-out part in end, as shown at *c c*; this being cut out to half the depth of the piece, so that when the two are put together, the one going mutually into the other, the faces of the two pieces are flush with each other, like a "half-lap" joint.

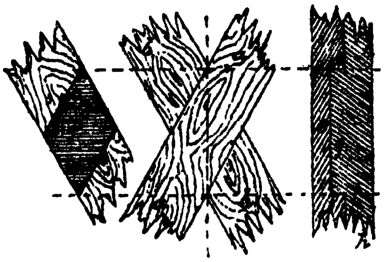


Fig. 51.

Pieces joined at Right Angles to Each Other.

In fig. 52 the simplest way of joining two pieces at right angles, as the piece *a* to *b*, the end of piece *a* stopping short at or being cut off or left flush with edge of piece *b*, is by placing the piece *a* on face *b* and securing them with nails. A neater and more secure joint of this class is made by cutting out a piece, as *i*, in the face of the piece *b b* at its upper end, shown in section at *e f*; a corresponding part is cut out at the end of *a*, as at *h* in *g*; the two when placed together are then flush on the surface. In joints of this class the mitre joint, as in fig. 53, is the neatest. The simplest way of making the joint is by cutting the ends of the pieces, as at *a b c d*, those lines being at angle of 45°, as shown by the dotted lines which show the parts cut off. When the two pieces are brought together the joint shows as at *e g*, the one piece at *e f* being exactly at right angles to the other piece *e e*. The pieces when meeting are secured by t[illegible]nails' or nails. The neatest joint of this kind is, however, made by the mortise and tenon joint at the angle.

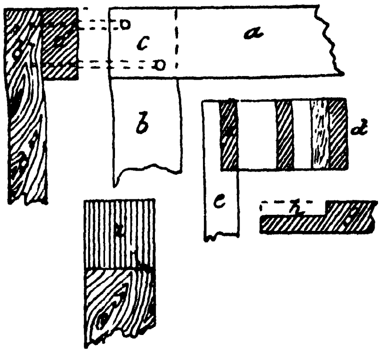


Fig. 52.

THE CALICO PRINTER.

THE CHEMISTRY AND TECHNICAL OPERATIONS OF HIS TRADE.

CHAPTER XII.

THE following is the table referred to at the close of the preceding chapter:—

Table showing Strength of Hydrochloric Acid according to the Specific Gravity.

Specific Gravity at 15° C.	Per cent. of HCl by weight.	Specific Gravity at 15° C.	Per cent. of HCl by weight.
1·0103	2·22	1·1504	29·72
1·0189	3·80	1·1588	31·50
1·0310	6·26	1·1730	34·24
1·0557	11·02	1·1844	36·63
1·0751	15·20	1·1938	38·67
1·0942	18·67	1·2021	40·51
1·1048	20·91	1·2074	41·72
1·1196	23·72	1·2124	43·09
1·1308	25·96		

Free hydrochloric acid, if sufficiently concentrated, injures cotton fibre, especially on steaming; and very minute quantities of this acid act very destructively upon many colours, especially alizarine pinks; hence it is frequently important to have drugs free from impurities of hydrochloric acid—as for example acetic acid.

Sulphuric Acid or Vitriol (H_2SO_4) is used chiefly in the discharging bath for discharge indigo-blue styles. It is also used in bleaching in place of spirit of salt. When pure it is a colourless, powerfully-acid liquid, of specific gravity 1·854; in commerce it is generally colourless, and about 170° T., containing 93 to 98 per cent. pure acid, H_2SO_4. The usual impurities of vitriol are lead, iron, nitrates, chlorides, arsenic, and organic matter.

Pure sulphuric acid, H_2SO_4, exists. Vitriol is the solution, or mixture, of pure H_2SO_4 with water; the former both in the crystalline and liquid state, according to the temperature and method of treatment; the best vitriol in commerce contains only 2 to 4 per cent. of water. It has a powerful affinity for water; thus, when added to water much heat is given out, and the temperature of the liquid may rise to over 212°. When exposed to the atmosphere it readily absorbs moisture, and is largely used in the laboratory for the purpose of drying gases, etc. Vitriol, even if largely diluted, rapidly destroys cotton; and free sulphuric acid should never be present in colours. If the largely diluted acid be applied to cotton and steamed, a more or less dark-coloured stain will be produced and the fabric rendered rotten.

The boiling point of sulphuric acid is 338° C.

The following table shows the results obtained by Kolb:—

Table showing the Amount of Pure Sulphuric Acid, H_2SO_4 in Solutions of different Specific Gravities.

Specific Gravity at 15° C.	Percentage of	Specific Gravity at 15° C.	Percentage of H_2SO_4.
1·006	·9	1·671	74·7
1·075	10·8	1·691	76·4
	20·8	1·711	78·1
	31·0	1·732	79·1
	41·6	1·753	81·7
1·410	51·2	1·774	84·1
	61·0	1·796	86·5
	70·0	1·819	89·7
1·634	71·6	1·842	100·0
1·652	73·2		

Nitric Acid or Aquafortis (HNO_3) is employed in making a few mordants and in engraving or rather etching copper rollers, also in discharge black or Turkey red. Pure nitric acid is a highly acid and corrosive fuming liquid, of specific gravity 1·45, and its most important property is its oxidising action, or its tendency to give up a portion of its oxygen, converting proto-salts of iron and other metals into per-salts, etc. The commercial acid generally contains iron, arsenic, and other impurities.

Nitric acid is a mixture of pure HNO_3 with water. On heating, the strong aqueous solution begins to boil at 86° C., a portion of the acid being decomposed; but when about three-fourths of the acid has distilled over, the residue is found to be a colourless strongly fuming liquid, containing 95·8 per cent. of HNO_3. When the strong acid is mixed with water an elevation of temperature and contraction of bulk takes place.

Table showing Amount of Pure Nitric Acid, Solutions of different

Specific Gravity at 15° C.	Percentage of HNO_3.	Specific Gravity at 15° C.	Percentage of
1·530	100	1·251	40
1·495	90	1·185	30
1·460	80	1·120	20
1·423	70	1·060	10
1·374	60	1·029	5
1·317	50		

Nitric acid rapidly acts upon cotton and destroys it. The largely diluted acid, when placed on the fibre and steamed, quickly rots the fabric.

A mixture of the two preceding acids, forming nitro-hydrochloric acid or aqua regia, occasionally is employed for making tin mordants. It has a more powerful action upon some metals than either of its component acids. It is occasionally made use of in making mordants colourless.

Acetic Acid ($C_2H_4O_2$) is very extensively used in calico printing. Its chief uses are in dissolving the aniline and other dyes, and tannic acid for printing; for adding to alizarine and other colours to cause them to "work" better in the machine—as starch thickens more evenly in presence of a little acetic acid than in its absence—and to keep the dyes in solution; also in making acetates by dissolving the base as oxide in it. Acetic acid, in combination with the metallic oxides, is largely employed in mordants. When pure, or glacial (*i.e.*, containing only 15 per cent. of water), it is a strongly acid and corrosive, colourless, readily volatile liquid, of specific gravity 1·0635, and boiling at 243° F. The commercial article is sold at different strengths; that at 8° T., or specific gravity 1·04, contains from 29 to 31½ per cent. pure acid ($C_2H_4O_2 + H_2O$); it is usually of yellowish colour, due to the presence of organic and other impurities. For use in alizarine colours it is required to be free of iron and copper, lead, and free hydrochloric acid.

Acetic acid, when mixed with water in different proportions, does not possess a specific gravity in exact proportion to the amount of acid present, as is the case with pure sulphuric and other acids. The density increases from 1·063, the specific gravity of the pure mono-hydrated acid, up to 1·0735, the specific gravity of the mixture containing 79 per cent. of acid; then decreases as the amount of acid contained in the mixtures decreases. Hence the strength of this acid can only be correctly ascertained by chemical testing.

Table showing Percentage of Acetic Acid, $C_2H_4O_2$, contained in Solutions of different Specific Gravities.

Specific Gravity at 15° C.	Percentage of Acetic Acid, $C_2H_4O_2$.	Specific Gravity at 15° C.	Percentage of Acetic Acid,
1·0142	10	1·0400	29
1·0214	15	1·0412	30
1·0284	20	1·0424	31
1·0298	21	1·0436	32
1·0311	22	1·0447	33
1·0324	23	1·0459	34
1·0337	24	1·0470	35
1·0350	25	1·0615	50
1·0363	26	1·0685	60
1·0375	27	1·0553	100
1·0388	28		

Anhydrous Carbonate of Soda.

Anhydrous carbonate of soda, Na_2CO_3, when added to water combines with it with production of heat. On evolving strong solutions of this salt, crystals of different hydrates are formed; one of which is the decahydrate, $Na_2CO_3 . 10H_2O$, hereafter described.

The anhydrous salt dissolves in water in the following proportions:—100 parts of water dissolve, at 0°C., 7·1 parts of Na_2CO_3; at 10° C., 12·6 parts; at 20° C., 21·4 parts; at 30° C., 38·1 parts; at 32·5° C., 59 parts; between 32·5° and 79° C., 46·2 parts; at 100° C., 45·4 parts; and at 105° C., 45·1 parts.

Soda Crystals.

Soda crystals dissolve in water with a slight rise in temperature. On exposing the crystals to the air they effloresce, or lose a portion of their water of crystallisation, and fall into a white powder consisting of the monohydrate. The crystals when heated to 34° C., melt, and on cooling form the monohydrate, $Na_2CO_3 . H_2O$.

Table showing Amount of Soda in Solutions of different Specific Gravities.

Specific Gravity at 15° C.	Percentage of Na_2O.	Specific Gravity at 15° C.	Percentage of Na_2O.
1·0163	1·20	1·3349	23·57
1·0764	5·44	1·3505	24·78
1·1528	10·27	1·3586	25·38
1·2392	15·11	1·3751	26·59
1·2982	20·55	1·3836	27·20
1·3053	21·15	1·4011	28·40
1·3143	21·89	1·4193	29·61
1·3198	22·36	1·4285	30·22

Table showing the Percentage of Caustic Potash, KOH, contained in Solutions of different Specific Gravities.

	Specific Gravity.	Percentage of KOH.	Specific Gravity.
1	1·009	40	1·411
5	1·041	45	1·475
10	1·083	50	1 539
15	1·128	55	1·604
20	1·177	60	1·667
25	1·230	65	1·729
30	1·288	70	1·790
35	1·349		

Table showing Strength of Ammonia, according to Davy.

Specific Gravity.	Percentage of Ammonia.	Specific Gravity.	Percentage of Ammonia.
·8750	32·50	·9255	19·54
·8875	29 25	·9326	17·52
·9000	26·00		15·88
·9054	25·37	·9435	14·53
·9166	22·07	·9474	13·46

Hydrometer Glasses.

Throughout this article frequent use has been made of the sign ° Tw.: thus, vitriol at 170° T., spirits of salt at 30° Tw. This refers to the scale of Twaddle's hydrometer or instrument for determining the density of a liquid. The density or specific gravity of water at a temperature of 60° F. is taken as 1° Tw., or 1 sp. gr.; and the hydrometer glasses are graduated from 1° T. up to 170° F., which is the density of vitriol; the scale comprising six glasses numbered 1 to 6. To convert degrees Twaddle into direct specific gravity, multiply by 5, add 1000, and divide by 1000. Thus, 6°T. × 5 = 30; 30 + 1000 = 1030, which divided by 1000 = 1·03, the specific gravity. If water be taken as 1000, then the last process of dividing by 1000 is omitted, and 6°T. will equal 1030 sp. gr.

THE GRAZIER AND CATTLE BREEDER AND FEEDER.

THE TECHNICAL POINTS CONNECTED WITH THE VARIETIES OR BREEDS OF CATTLE—THEIR BREEDING, REARING, FEEDING, AND GENERAL MANAGEMENT FOR THE PRODUCTION OF BUTCHERS' MEAT AND OF DAIRY PRODUCE.

CHAPTER XIV.

Some Points connected with Fat Cattle fed exclusively for the Butcher (*continued*).

AT the conclusion of preceding chapter we stated that much of the food consumed by animals up to and below the point of maturity, or what is called "prime condition" for the butcher, goes merely to strengthen their bone and form their frame: when this is completed, then the food consumed, if administered properly, goes to the true fattening process, as described above. But the point of maturity, or "prime condition for the butcher," at which the food taken or a portion of it goes to the formation and strengthening of the framework of the animal, varies much in different cattle and in different breeds. Hence it has long been the aim of "the grazier" to produce or improve a breed which not only fattens quickly, but which matures quickly. Of all the breeds the shorthorn excels in these respects; as a rapid fattener—that is, in quickness of increase in carcase or meat weight—it is unrivalled. But as compensating for a deficiency in those qualities just named in other breeds, it is well known that those beasts which fatten more slowly than the shorthorn produce frequently a better internal development, giving a larger and finer supply of fat, suet, and tallow—a certain time being obviously required to give the best results.

But, important as the points are which, up to this stage of our papers, we have been discussing—essential, indeed, as they are—still they refer solely to the animals themselves and. their peculiar characteristics, while there are other points which affect their condition as producers of meat, which are independent of the animals themselves, being imported into the general field of nature from without. Of these the first and most obvious is the food upon which they are fed, and the way in which it is administered. While it is true enough that there are animals better fitted to fatten quickly and economically than others, the good or well-bred animals making the best of the food—putting it, as the popular expression has it, into a good, the bad or ill-bred animals putting it "into an ill skin"—still the fact is incontrovertible that in both cases good food *per se* will give infinitely better results than bad. But the best results are dependent not only upon the good quality of the food, but on the way in which it is given. All the details connected with this point, of the highest importance to the grazier, demand a close investigation and explanation. This will be given in a series of succeeding or future paragraphs, which will embrace the whole question. Not less powerful as a factor in the general question of rapid and economical fattening is the condition of the health of the animals. This also is a point of such vital importance to the grazier—involving as it does the general management of a herd of cattle—that special space will be given to its discussion in succeeding paragraphs. In concluding our special remarks on the breeding of cattle and cognate points, enough has been given to show what is demanded of the grazier before he can become successful in his calling. This includes likewise great power of observation, quick, ready, and precise, a knowledge of more than one branch of physical science, combined with the perseverance, prudence, and skill without which no business can be quite successful, certainly not that of grazing. From what has been given it will be seen that from the grazier who determines to be a successful breeder a very wide extent of knowledge is demanded. This involves not merely attention to the points which influence the form of the animal and the quality of the flesh or meat which it produces—points which, as we have seen, require to be carefully and thoughtfully studied—but the closest of attention to the details of general management, food, feeding, and health. This department of the grazier's work is of the highest importance, although in the discussions which take place on the general subject it is but too apt to occupy a secondary place, being overshadowed by, to many minds, the greater question of breeding. But that the two departments—"breeding," that is, getting the best animals to fatten early and quickly, and "management," that is, the art of fattening or feeding so as to obtain these desiderata—*must* go together if the highest, that is the best paying success be desired, is beyond all doubt the true principle. This point may receive a familiar enough illustration. For it would be of little use to put down a steam engine which possessed all those points of arrangement and construction which enabled it to give the highest effective duty in working, if in the very employment of it we carelessly or heedlessly managed it so that the points which made the engine the complete machine it was were not allowed to operate, or so operated that they had no chance of displaying their best and most economical characteristics. If in such a case one used the poorest quality of coals, and this moreover in the most careless of ways in stoking or firing up—if one failed, by being careless, to get the right quality and the proper pressure of steam—and if, in addition to all this, one paid no attention to the peculiar features and adjustment on which the economical value of the engine depended—the common-sense conclusion would be inevitably but in one direction, which might be expressed thus:—"You took every care and went to great expense to procure an engine of the highest class, possessed of all the improvements which the most recent developments of science and experience showed gave the highest efficiency in economical working; and having procured it, you proved how little you valued all these by not only neglecting them, but by employing the worst materials and using them in the worst way. You would have been wiser had you, with such a style of careless management, purchased some common form of engine, which demanded no great care and involved no such expense." Such considerations may be very commonplace, but it is by the neglect of very commonplace things that so much loss is incurred in the conduct of every class of business, or of work. However careful, then, the grazier may be in procuring good animals, he should be no less so in carrying out all the details of the best system of management open to him. What this system is will engage our attention in the succeeding paragraphs; and from what we have to give it will be seen that the general management, including as this does food, methods of breeding, and maintenance of health, demands from the grazier a wide extent of knowledge, the habit of closest observation, and the most careful attention to details. But it is not alone to the animals—that is, the breed chosen by the grazier—or to their general management, that he should confine his attention. These departments, although they include nearly every point, do not include all. Attention to the conditions in which the animals are placed, to the circumstances by which they are surrounded, must also be given. This will demand care on the part of the grazier and breeder as to the choice of his pasture fields, their locality as to shelter, the arrangement and construction of the buildings in which his cattle are kept, so that the most be made of the food they consume, the choice of water, and the "thousand-and-one" things which minister to the comfort and the health of the stock. The most careful attention must be paid to the various circumstances surrounding the animals; and it is difficult to know at times which of these may most materially affect the purity or points of the breed, or their health and general condition.

The most watchful care is indeed demanded, so that no point at all likely to affect the animals may be overlooked. For example, some of our readers may be surprised to learn that one of our most eminent breeders, who was famous for his stock, which were of pure black, was most careful in having all the gates of his fields, and of the fold—everything, indeed, about his farm which could be painted—painted a black colour. The necessity for this and such-like points was forced upon him by experience, this pointing out to him the remarkable influence upon the stock of imagination or liking for certain things such as colour. At one time he had put up some of his black along with some of the red stock of the south of England, and the result was a change in some of his own breed from black to red, which taint could only be got rid of by two or three years' weeding, and only after the red cows were removed and the black cattle ever after kept free from the red cows pasturing with or being near them. It is on record also, in this connection, that a celebrated aristocratic breeder of shorthorns found that the favourite colour—roan, which is a compound colour, red and white—of the breed, was becoming tainted with white calves, the cause of this supposed to be in the white paint used for the painting of the gates. This was given up, and the proper colour substituted; after which the taint was gradually got rid of, and the roan became richer and darker. This may all be put down to fancy, as some indeed have done; but it is not so. For it is a fact in breeding which all experience has proved the truth of, that there is scarcely any point which can be so certainly determined as that of colour. One of our ablest authorities on this point says: "I am as positive as I am of my own existence that a uniformity of colour as unvaried as any other class of animals could be secured (in shorthorn cattle) in process of time, if breeders were unanimous in determining upon one of the three—red and white (*i.e.* roan, the favourite colour), pure white, or red." In illustration of the truth of this, and in view of the facts we have above stated, which may be taken as the highest developments of modern breeding science, as an illustration of the saying that "there is nothing new under the sun," the reader versed in Scripture will remember an instance of the theory and the practice of this feature in breeding as given in the life of Jacob. Enough has been, but if space permitted much more, and usefully, might be given, on the important subject of breeding, the points of which noticed in our various paragraphs lie at the very base of all successful practice. But from what we have found space to give, the reader should learn much—enough, at all events, to learn more, and to induce him to devote his closest attention to all circumstances, however apparently remote, to all details, however minute. By this, and the exercise of patient and close observation, by the study of what the best breeders have done, and by the study of the various branches of science hereafter in succeeding paragraphs indicated, success in practice of the highest kind can only be secured. And with less than this the young grazier should wisely determine not to be satisfied. And this ambition will be a worthy one, for in its actual, or at all events closely approached attainment, he will have the satisfaction not only of gaining the usual rewards of success; but, what from a higher point of view is of greater importance, he will by this minister to the mutual well-being of his fellow-countrymen, and lay them and succeeding generations under an obligation of the highest social value. If it is true, as has been said, "that he who makes but two blades of grass grow where but one grew before" deserves the highest gratitude of his kind, it is no less true that this reward belongs to him who adds to the value or increases the number of improved breeds of cattle fitted for the supply of the population, as flesh meat consumers.

In the preceding paragraphs we gave a general view of the principles and practice of the breeding of fattening cattle. We now proceed to the consideration of the points connected with their feeding and general management. As introductory to our remarks on these important subjects it will be necessary to glance at the principles upon which feeding is based, and the leading characteristics of the substances used as food considered in relation to those principles. Of late years a great advance has been made in the quick and economical feeding of cattle. Not only has the aid of science been called in to tell the feeder what are the constituents of the various substances he uses as foods for his live stock, but it informs him as to the parts those constituents play in the frame and forming the flesh of the animal which consumes them.

The details connected with what is now, and justly, called the "science of cattle feeding," afford a remarkable exemplification of the mutual dependence which exists between the various developments of animal and vegetable life, or what has been by some called the "circle" or "cycle" of physical or animal existence or life. Science tells us that the existence, the growth, and full development of animals depends upon the existence of certain constituents in the foods on which they live. As animals, so plants, are made up of two parts or classes of substances—"organic" and "inorganic," or in other words, of "vegetable or combustible"—and "mineral or non-combustible" matter. The chief organic or combustible parts of the bodies of our animals are found by the researches of chemical science to have their representatives in plants. Thus we find that animal fibrin, albumen and casein, which make up its flesh, are identical with the muscle or substances having like name found in plants, which make up what are called their "nitrogenous" parts. And as the fat of animals finds its representative in some constituents of plants which make up their non-nitrogenous parts, so in like manner the mineral constituents of our soil are essential to and are found existent in our growth of plants. Now, these mineral constituents have their representatives in the bone, flesh and general tissues, and are greatly essential to the growth of the animal. Thus we find that while in the animal frame certain constituents are derived from the non-mineral parts of plants, we find others—as the phosphate in the bone, the alkaline earths in the flesh, and the phosphorus in the blood, the nerves and the brain—derived from and sustained by the mineral constituents of plants. While treating of the soil and of manures in relation to crops, we gave in the series of papers entitled "The Farmer as a Technical Workman" a statement of the constituents present in soils, and showed their relation to the plants or crops grown in them. From the following it will be seen that by the consumption of these crops those constituents are transferred to the animal. Thus, taking the blood of an ox as the representative of its life,—"for the blood is the life thereof,"—and how this life is maintained by food, we see how necessary it is that the soil from which those food crops derive these constituents should be so economically treated that there shall be a good supply of them in the soil—thus in another direction illustrating the cycle of farming work. Of those mineral or organic constituents of soils there are present in 100 parts of the blood of an ox, of phosphate of soda, 10·77; chloride of sodium or common salt, 59·34; chloride of potassium, 6·12; sulphate of soda, 3·85; phosphate of lime and magnesia, 4·19; oxide and phosphate of iron, 8·28; gypsum, 1·45.

The constituents of all "feeding stuffs," as food for live stock is technically called, are classed under one or other of these two divisions:—First, the "organic," or those subtances which are capable, and, second, the "inorganic," or substances which are incapable, of being consumed. Let us glance first at the organic substances of food; and the first point which attracts our attention in respect to them is, that their constituents are classed under one or other of two subdivisions:—First, the "nitrogenous," and, second, the "non-nitrogenous" substances. The nitrogenous are also called "flesh-forming" substances. In these nitrogenous substances the four elements of carbon, hydrogen, oxygen, and nitrogen are all present, and go to form what are called vegetable albumen, casein, fibrin, or gluten. In the animal we find representatives of all these—as in the albumen of the white of an egg, the casein in the curd of milk, and fibrin in the fibrous part of flesh. All these substances of plants go to make up, when partaken of by the animal, its fully developed frame, to form the blood, the flesh and the muscle, and to make up for the waste of the animal tissues and supply their juices. In the non-nitrogenous substances, of food elements alone present are carbon, hydrogen, and oxygen; the fourth, nitrogen, being always absent.

THE FARMER AS A TECHNICAL WORKMAN.

HIS TOOLS, IMPLEMENTS, MACHINES AND MATERIALS. —THE PRINCIPLES OF HIS WORK IN ITS VARIOUS DEPARTMENTS.

CHAPTER V.

Proposed Arrangement of the Subject of the present Series of Papers.—General Treatment of its Details.

IN taking up in regular order, for a more or less detailed description, the various departments of farming as technical work, the leading features of which occupied our attention in the course of the preceding chapter, there are several methods of arrangement and treatment open to us. We might, for example, adopt the arrangement which takes up the whole gradation of farm work comprehended within the course of a year—either in the ordinary sequence of the months, beginning with January and ending with December, or in the more philosophical sequence of the months of the farming year, which begins with the preparation of the soil for seed sowing and the autumnal cultivation in the month of October of one year, and ends with the harvesting of the resulting crops in the month of September in the year following; the breeding, rearing, feeding and fattening of live stock of all kinds running on throughout the whole of the year. Or we might take that arrangement of the complete subject which is most frequently adopted, and which, if it be not the most scientific, is, taken as a whole, the most systematic mode of treating it. Under this arrangement, the materials at the command of the farmer, and with which and through which he carries on his work of crop cultivation and cattle rearing, we take in their sequence; commencing, for reasons which will be obvious, with the soils, then going on to manures, thereafter taking up the subject of seeds, next considering the various methods of preparing the soil for the reception of the seeds and the manures used with them, and the after-cleaning or weeding and cultivation of the crops up to a certain stage of their growth, and finally, the various methods of harvesting and storing up of the produce of the various crops. Incidental to, or forming rather an integral part of all those departments, the points of scientific interest, or rather the principles of those sciences which affect and control the practice of the farm, would also be considered. And in close connection with all those, the details of what may be called the permanent work and appliances of the farm, such as of road-making, fencing, planning and erection of buildings, drainage and irrigation, would be noted, together with the selection, use, and care of the wide variety of machines and implements now at the command of the farmer; while every detail connected with the selection, breeding, rearing, feeding, fattening and general management of the live stock would follow: the whole concluding with an explanation of the various points connected with what may be called the administrative or business economy of the farm; such as the management of labour, and the buying and selling of materials and stock, or what may be called the commercial aspect of the farmer's calling.

The Treatment of Several Departments of General Farming relegated in this Work to Special Papers on the respective Subjects named.

But while this last-named method of treatment might with advantage be adopted in a special and separate work, the reader will see that the general principle upon which our work is based precludes, and for obviously useful and practical reasons, its being followed. The main feature of the work is the giving in its pages a special and distinctly marked position to each separate technical trade, and to such of the many industrial processes of the kingdom as have been selected for description and illustration. Under this plan, therefore, it so happens that many of the subjects we have just named as forming part of the general subject of farming, treated under the suggested plan of discussing it, have elsewhere in the pages of our volumes special places allotted them. Thus the details of drainage as applied to farm lands will be found described and illustrated in the special series of papers entitled "The Land Drainer." In the same way all the points connected with the employment of water as a fertilising agent for crops, applied in a systematic way, will be met with in the series of papers entitled "The Land Irrigator." And so with the details connected with the roads and fences of the farm, which will be found illustrated and described in the papers which bear the title of "The Road Maker." Again, the aid of the engineer and machinist being essential to the providing of the farmer with the wide variety of tools, implements, and machines which the requirements of advanced agriculture demand,—and as so many points connected with these mechanical appliances come so peculiarly within the province of the machinist, while the trade which he has formed, considered merely as one which forms a large item in the general business of the kingdom, has reached to such a point of importance that the whole subject demands a special treatment of it,—this, therefore, will be met with, by those interested in the subject, farmers and machinists alike, in the series of papers entitled "The Agricultural Implement Maker." And although not specially devoted to the subject, still much of practical value to the farmer in relation to his buildings will be found embodied in the various papers which bear the titles of "The Home Planner, "The Sanitary

Builder and Engineer," "The Stone Mason," "The Carpenter," "The Joiner," "The Bricklayer," and cognate trades and callings, such as "The Plumber" and "The Painter"; and last, but not in any sense least, the highly important subject of the live stock of the farm, comprised under the general head of the Breeding, Rearing, Feeding, and General Management of the animals which make up a large part of the food of our population, are being treated of in a special series of papers under the title of "The Grazier."

From these statements it will be perceived that the treatment of the technical work of the farmer, so far as the present series of papers is concerned, will be given within much narrower limits than those traced in the method of treatment of the subject as a whole which we have above named. Thus narrowed in its scope, the subject will be treated under the following divisions:—First, the tillage or mechanical treatment of the soil as a means of preparing it as a seed-bed. Second, the soils of our farms, their different classes and peculiarities, chemical constituents, fertilising ingredients, etc., etc. Third, manures and manuring substances, their action in the soil and on the crops, their different kinds or classes, chemical constituents, and use and management in the practical work of cropping. Fourth, the crops of the farm.

The Working or Mechanical Treatment, commonly called the Cultivation, and more accurately the Tillage, of the Soil. —Important Aid given by the Mechanic and Machinist to the Farmer in this essential part of his Work.

Amongst the varied, and in character varying aids, of the highest value to his practice, which the farmer has had placed at his command during the last three or four generations, none possesses so many striking features as the work done by the agricultural mechanic, as none has given him more practical help. This has been more notable during the last two or three decades, throughout which not only have the vast improvements made in workshop practice, aided by a wide variety of workshop appliances, machines, tools, and improved qualities of materials, enabled him to turn out in greater variety and in higher and more perfect finish the numerous machines now in daily use, but by the application of steam furnished him with a power for doing more work with greater economy, and opened up a future in all departments of farming of rapid progressive improvement, of which we have as yet obtained only a very remote and feeble conception.

General View of the Mechanical Aids at the Command of the Farmer in carrying out his Work of Tillage of the Soil.—The Plough, Harrow, Roller, Corn Drill.

It seems but a simple statement to make that the first agricultural work attempted would be to get the seed buried in the soil; and yet, simple as this seems to be, it carries with it that long train of work, and the employment of those varied, and, even at this late day, ever-varying classes of cultural appliances, which form not the least striking feature of our modern agricultural exhibitions. Simple as the mere deposit of seed in the soil seems to be, it is in its philosophical or scientific aspects, and as offshoots of those in its mechanical outcome, anything but so. Ploughing—to start at once with the modern name for the operation—is indeed an art which involves the use of mechanical arrangements founded upon principles of a very high order. These we shall have occasion to point out when we come to discuss the most recent forms of ploughs, and some of those important modifications which the necessities of a new and higher order of culture demands.

For a long time the plough, for opening up the soil to receive the seeds, would be of the rudest and simplest form, and would do but little more service than simply to scratch the surface, or form ruts in it. Into these scratchings the seed would be thrown in equally rough and rude fashion by the hand. The next operation would be covering in, or up, of the seed so cast in, and this would probably be done by dragging over the surface the rough branches of a tree—represented even at the present time by the "bush harrow"—and on the smaller scale simply by the hand alone, or aided by a branch of a tree, still used in some farms. As time went on, and improvements were introduced, the plough would assume a form calculated to give seed-beds with greater precision, both as to depth and breadth; and the covering in of the seed would be effected by a frame, more or less rude, provided with teeth or "tines," which, while they would scratch or "scarify" the surface of the soil, would also cover the seed in more regular lines. In time it would come to be observed that in certain soils, and at certain seasons, the soil would get hardened into clods or lumps, and these would be seen to exercise a prejudicial influence upon the after growth of the plants. Means, therefore, would be sought for to reduce those clods to the condition of pulverised soil; and this probably would be at first done by the simplest form of implement—the hand-worked mallet of wood. In time the circular motion of a heavy body would be observed to be beneficial—suggested in part by the parallel working of the tree or bush harrow—and part of a trunk of a tree would be used. Thus, to the plough and the harrow would be added the roller—such as they early and for long were.

These three implements would form—and so far as history is traceable, did form—for a long period what might be called the three rudimentary implements of agriculture.

SUPPLEMENTARY SECTION.

CONTAINING PRACTICALLY USEFUL NOTES, TECHNICAL NEWS, AND CORRESPONDENCE.

TECHNICAL FACTS AND FIGURES IN OCCASIONAL NOTES.

EMBRACING THE VARIOUS DEPARTMENTS OF TECHNICAL AND INDUSTRIAL WORK, SUCH AS MECHANICS AND MACHINE DESIGN AND CONSTRUCTION — BUILDING DESIGN AND CONSTRUCTION—GENERAL MANUFACTURES, AS TEXTILE AND METAL—APPLIED OR MANUFACTURING CHEMISTRY — INDUSTRIAL DECORATION—SANITARY ENGINEERING—GARDENING AND RURAL MATTERS—MISCELLANEOUS.

150. Ensilage considered in relation to the Value of its Produce as a Food for Farm Live Stock (see Note 149, p. 28).

WE stated at conclusion of last note under this head that it would seem, from what was then advanced, that this would involve a recommendation that silage in bulk was the only food to be used. But although this would appear to be involved in the statement, in reality it is not included in the method. We must bear in mind what we have already stated, and which we think of special importance, that the silage is not to be given as the only food, or in bulk, but is to be used along with other and ordinary or dry food, the silage giving the element of succulence, and more than that, its own peculiar feeding value. But by having different silos, each—or a set—devoted to its own particular crop of silage, a power of varying the food will be given which, after trial, will be more and more highly esteemed. The more the point is considered, the more clearly it will be seen that much of the future of stock feeding generally, especially of dairy stock feeding, will depend upon the close study of the habits of the animals, and the application of this to the different details of their treatment. As a rule there has been vastly too much of the "rule of thumb" mode of treating farm stock—too great a satisfaction with old established methods, simply because they are old, and being so must be good. "Our fathers before us did this: are we wiser than our fathers?" is a saying the spirit of which has influenced too powerfully those who have had to do with the breeding, the feeding and the general management of the live stock of the farm. We have heard much of the science of cattle foods, and to it farmers have been greatly indebted; but there is a science of cattle feeding, concerning which we only remark here that it is one which involves, roundly stated, vastly more than chemical considerations,—physiological points as well. And we have little hesitation in saying that it has been to the great loss of the farmer that physiology has played so trifling a part in the general science of the farm. So trifling, that many smile, some indeed sneer, at the mere mention of this science as one which ever can possibly have anything practically to do with farming.

With reference to one point which has been raised in connection with ensilage food, it is necessary to make a remark. This point, or rather objection which has been raised to it, is that the use of silage has a tendency to interfere with the breeding powers of live stock. How this notion has arisen has not been recorded; we suspect that it took form and shape with, and was promulgated by, one of that class whose chief pride seems to be in not merely pooh-poohing new things generally, but in trying to find out some special point in which they are defective. And this they usually act upon in such a way as to give it a specious appearance, as if there were a vast deal of truth in it—taking care that the objection is connected with a point of great importance *per se*, such as the one we are now considering. People of this class are not unknown in farming, any more than in other classes of work, and they do infinite mischief. It is difficult to see why silage should impair or affect physically the breeding powers of stock, the only point which is apparently vulnerable being that the silage is a fermented food. But not only analogy, but a pretty wide range of experience, would show that in place of the peculiar kind of fermentation which silage undergoes acting prejudicially upon animals, it should have the reverse influence. If rye greatly diseased with that disease known as "ergot" were used exclusively as the silage food, we might conceive that it would have a tendency to produce abortion, as in cows ergot of rye has an unfortunate tendency in this direction. But the objection which has been made to ensilage food is not on this specific and narrow ground; it is wider in its scope or range, implying that its use has *per se* a prejudicial influence on the breeding capability generally. It is only right to say that such experiments as have as yet been made to test this point specially, have shown decidedly that silage, if properly used—that is, with care and forethought—has no tendency in the direction named. And this proper use of silage, while it involves more points than one, includes as the most important that to which we have already drawn pointed attention—namely, that the silage be not given as the only food, but that it be mixed with other foods. And as a general rule, which may be safely followed as regards the physical or mechanical condition of the foods, used together—silage being the succulent element, indicates that the other food should be dry.

151. Recent Researches into the Nature of Friction.

We concluded our last note on this important subject (vol. ii., p. 242)—than which there is none within the range of physical science more directly interesting in all its aspects to machinists—by some remarks as to the friction of quiescence, to which we would counsel our young reader again to refer. We concluded by saying that Morin found the "friction of quiescence" so called was subjected to variations which are not met with in the friction of moving bodies, or what may be termed the "friction of motion." This uncertainty as to results did not seem to depend upon or be under the influence of the extent of the surfaces in contact, for in the experiments made with bodies the surfaces in contact of which were alike in extent, but under different pressures, the "coefficient" of the friction—that is, the ratio or proportion of the friction to the pressures—varied very much. Had this variation in frictional effects independently of the surfaces in contact been found to have been a characteristic of bodies in motion—that is, in which the "friction of motion" existed—General Morin might well have despaired of finding out or formulating rules for the guidance of mechanics dealing with machinery, in which of necessity the chief feature is *motion* in its various parts. Fortunately this uncertainty as to the friction which was found to exist in the case of what is called the "friction of quiescence," or of that which may be termed "statical friction," was not found to exist in the manifestation of the friction of motion, or what may be termed dynamical friction. For as the result of an extremely wide range of experiments, and doubtless to the great satisfaction of M. Morin, as removing a difficulty in formulating precise and definite principles and data, which otherwise had been insuperable, he found this. That the slightest change in the relative position of the two surfaces in contact, the slightest jar or shock to which the bodies in contact were subjected, brought about at once a total and complete change in the conditions of friction; the new condition thus created possessing features or characteristics quite different from those of the friction of quiescence, and belonging wholly to the friction of motion. Different in this altogether important and satisfactory respect: that whilst we have seen that the friction of quiescence is subject to great variations, in no way dependent upon the extent of the areas or surfaces in contact—inasmuch as the coefficient of friction, or the ratio of the friction to the pressure, was different, although the surfaces in contact were the same—the new experiments showed beyond all doubt that when the bodies in contact were changed in condition, so that from the position of the surfaces, slight shocks or jars were given to the bodies, the friction obeyed laws which were distinguished by remarkable precision and definite characteristics. And this not only in regard to the dimensions of the bodies, or the area or extent of the surfaces in contact, but also with regard to the pressures to which they were subjected. To make certain this important fact, or rather in order to show that it is a fact, not a mere assumption, General Morin instituted a series of experiments which gave an extremely wide range of variations in character; and he found in all that the laws dominating the friction of motion were entitled to be so called, as they possessed the necessary character of unvarying precision. How fortunate this was for the machinist the young reader will perceive, inasmuch as motion in the parts of machines—that is, a change in the position of the surfaces in contact—is their chief characteristic, and this motion may be further conceived to be a continuity of the slight shocks or jars which M. Morin found to be necessary to create the condition designated as the friction of motion. The "laws" formulated by this distinguished authority, and which, as we have said, were accepted and acted upon by practical men, and dominated the minds of the great majority of engineers and machinists up to within quite a recent period, are as follows. (*a*) That the friction created by or which accompanies the motion of two surfaces in contact, and between which there is no lubricating substance or unguent interposed, bear always the same proportion to the pressures or force to which the bodies are subjected and by which they are pressed together in contact—and this whatever be the amount of the force or pressures. In other words, the ratio of the friction to the pressure is invariable; and this is, as we have seen, technically called the "coefficient of friction." And this varies with the nature of the substances or bodies in contact: the coefficient of friction of a cast-iron body in contact with and in motion upon another body also of cast iron being different from the coefficient of a body of cast iron in motion upon another body of brass. The second law formulated by M. Morin was (*b*) That the friction of motion is quite independent of the area or extent of the surfaces in contact. The next was (*c*) That the ratio of friction to the pressure, or the coefficient of friction, varies with the conditions under which the bodies are placed. Those conditions are three in number—the coefficient being in each separate condition or state invariable throughout; but it is essentially distinct and different in the three different conditions or states. These are as follows: (1) Where the surfaces are simply unctuous or what may be called greasy, and intimately or very closely in contact; (2) where there is an unguent or lubricating substance interposed between the surfaces in motion—

that is, the condition known as ordinary lubrication, as where oil is passed through the cap of a pedestal, passing downwards to and oiling or lubricating the journal or bearing of the shaft more or less unequally; and finally (3) where the two surfaces are wholly separated from each other by an interposed stratum of the lubricating substance or unguent—that is, for example, where the journal of a shaft is, so to say, suspended in a bath of oil—the surfaces, that of the journal and those of the brasses or bushes, being thus prevented from coming in contact by the stratum or film of oil or other lubricating substance. These conditions or states bring therefore into existence this consideration: that the second law (*b*)—namely, that friction is independent of extent or area of surfaces in contact—must be taken or received in the case where a lubricating substance is interposed, as in (3) under third law (*c*), only within certain limits. For the young reader will perceive, in thinking out the condition named in (3) under third law (*c*), or that in which the one surface is prevented from coming in contact with the other surface by the interposed stratum of a lubricating substance, that whilst under a certain pressure this condition will be maintained, and the body suspended, so to say, by the stratum of the lubricator, that pressure may be so increased that the lubricating substance, as oil, may be squeezed or pressed out; and this to such an extent that this condition (3) may be changed into the condition (1), both under third law (*c*), and which condition is that in which the surfaces are simply unctuous or greasy, but in intimate contact with each other. So long as those two distinct and different conditions, (1) and (3) under (*c*), exist, the second general law of friction (*b*) holds good—namely, that it is independent of area or extent of surfaces in contact. But it is obvious that the transition state brought about by the increase of pressure, where condition (3) is passing into condition (1), both named under (*c*), must be represented by different stages, so to say, beginning with the period when the squeezing-out or increased pressure is put on, and ending when it is completed. For with the interposed stratum of lubricating substance the one body is sustained, or so to say suspended, under the given or normal pressure; but when the condition is changed, the portions or parts of the surfaces so suspended become continually diminished; the portions or parts of the pressure which press or bear, so to say, upon each part or element of the surfaces in contact will then be continually increased, giving a succession of stages to the transition state between (3) and (1) under (*c*), till the whole of the interposed stratum or suspending film is pressed or squeezed out, and the condition of (3) changed into that of (1) under (*c*). We thus see that there are three conditions of friction into which surfaces of bodies in contact may be made to pass, or under which they exist; and that in each condition the coefficient of friction—or ratio of friction to pressure—is the same; but that this coefficient is essentially different from that of another condition. This was illustrated by a very complete series of facts, the results of experiments made by General Morin, showing the coefficient of friction of a wide range of bodies in contact, all of which have been accepted, and published, not always with an acknowledgment of their source, by almost every writer on the subject, from the time of their publication by M. Morin till now. We now come to the fourth and last law of friction formulated by General Morin—namely, (*d*) that the friction of motion of all the states or conditions under which two bodies are in contact, (1) (2) and (3) under third law (*c*), is quite or altogether *independent of velocity, or the rate or speed of the motion.* This statement of the investigations made by General Morin into the nature of friction, and of the laws which he deduced from them and formulated, brings us to the more or the most recent investigations and experiments which form the basis of this series of notes. What has yet to be given about these will be found in succeeding "notes."

152. When the Breadth, the Thickness, and the Weight are given of Wrought Iron Plates, to find the Length.

Take the breadth and multiply it by the thickness, and with the product as a divisor, divide the result by multiplying the weight by 3·6: the quotient is the length required.

153. Weight in Pounds of a Square Foot of Cast Iron of Thicknesses from 1⅝ up to 3 inches. [*See* Note No. 30 (3), vol. i., p. 188.]

1⅝ inch thick = 60·93 lb.; 1¾″ = 65·62; 1⅞″ = 70·31; 2 inches thick = 75 lb.; 2⅛″ = 79·68; 2¼″ = 84·37; 2⅜″ = 89·06; 2½″ = 93·75; 2⅝″ = 98·43; 2¾″ = 103·12; 2⅞″ = 107·81; 3 inches thick = 112·5 lb. per square or superficial foot.

154. Screw Threads in Use. French Common Standards. [*See* Note No. 103, p. 110, vol. ii., for "Whitworth" standard.] (1) Diameter in Millimetres. (2) Pitch in Millimetres.

(1)	(2)	(1)	(2)	(1)	(2)
	0·5	15	2	32	3·5
	0·75	18	2·5	35	4
	0·75	20	2·5	37	4
	1	23	3·0	40	4
	1·25	24	—	42	4·5
	1·25	25	3·0	45	4·5
		28	3	47	5
10		30	3·5	50	5
	1·75				

THE DOMESTIC HOUSE PLANNER (*see Text*).

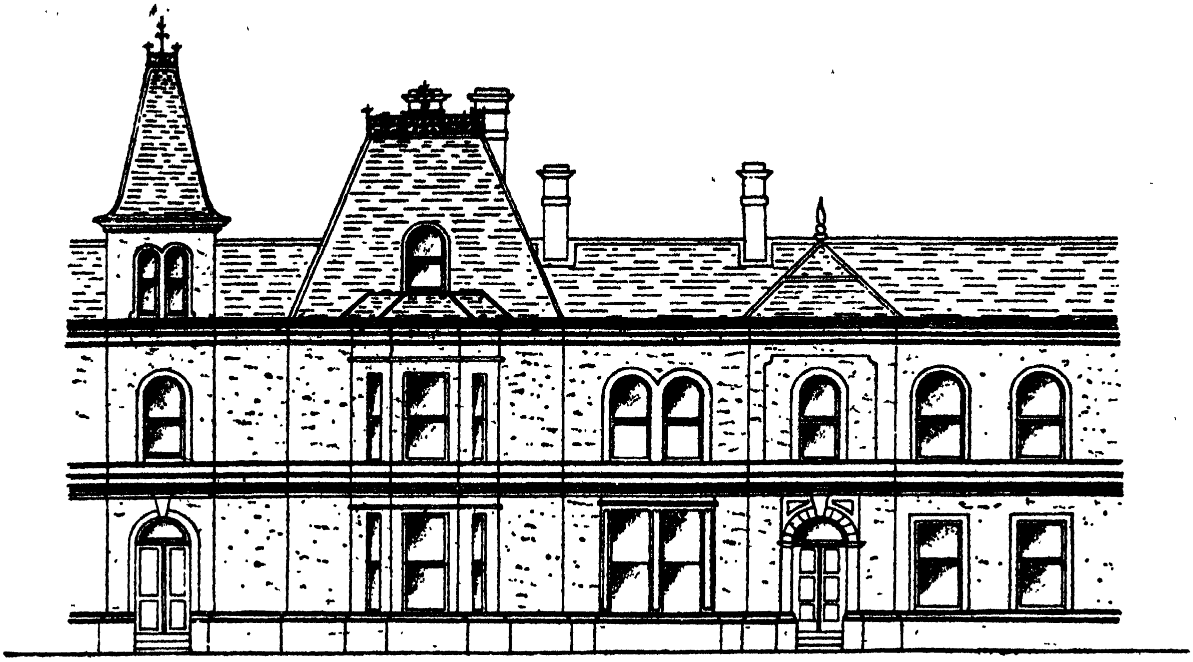


FIG. 1.

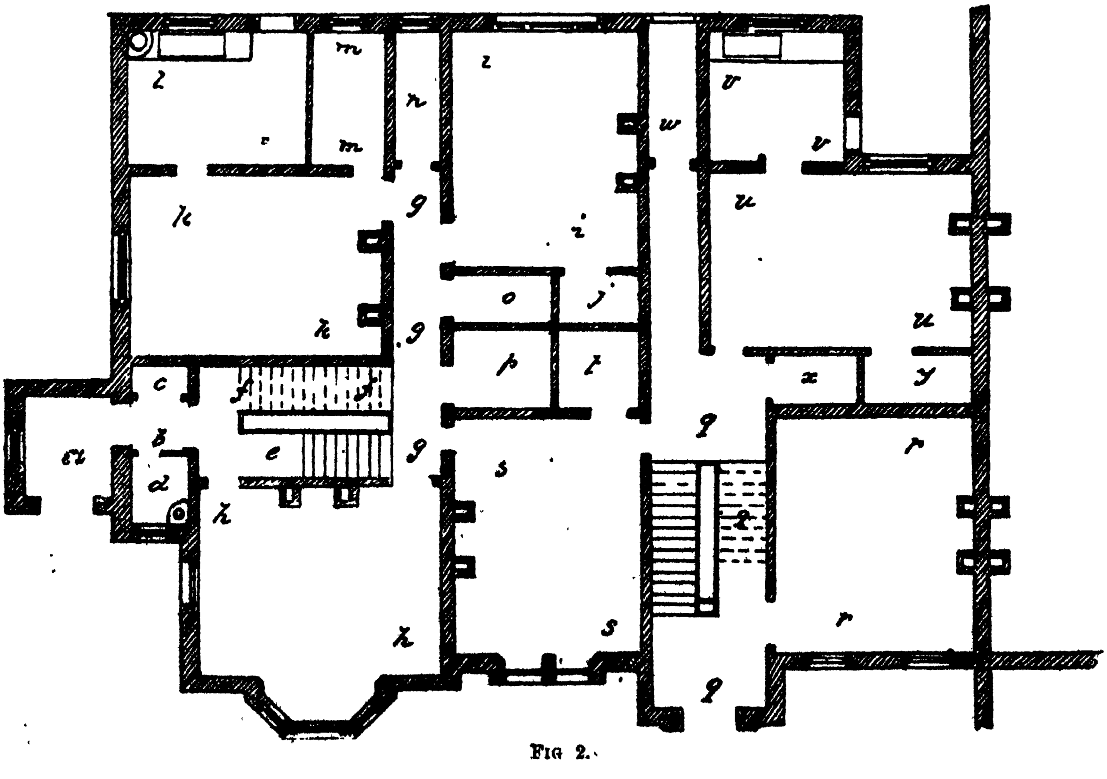
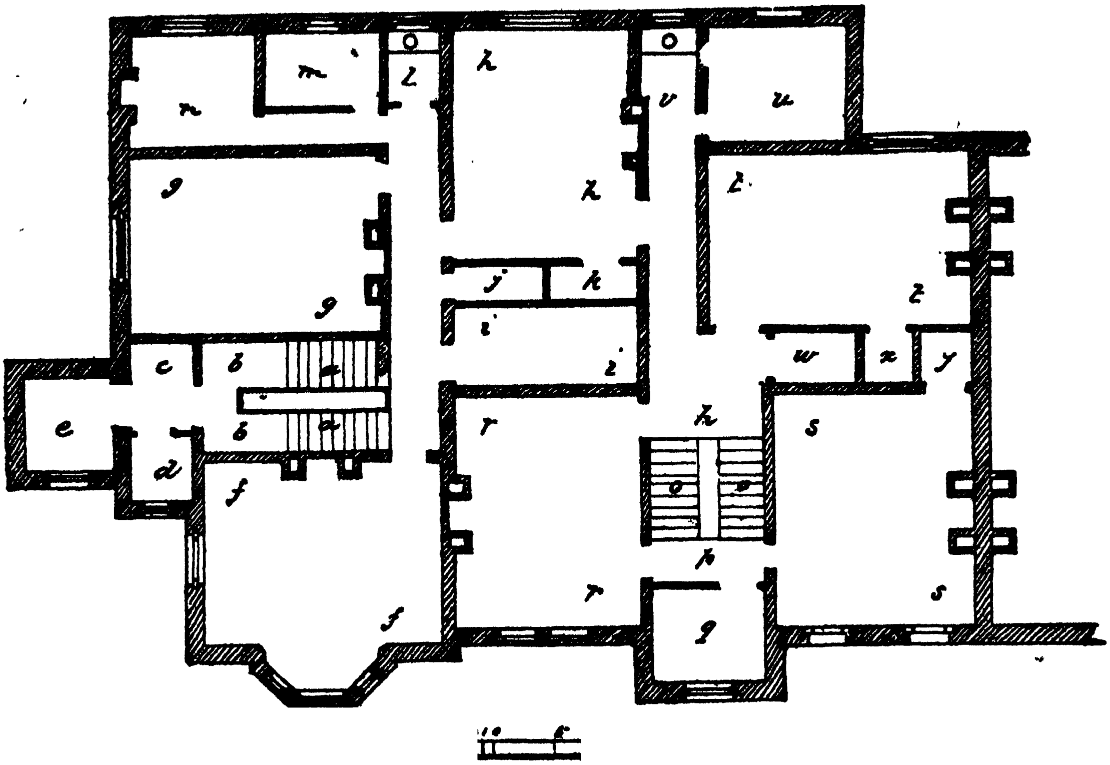


FIG 2.

THE DOMESTIC HOUSE PLANNER (see



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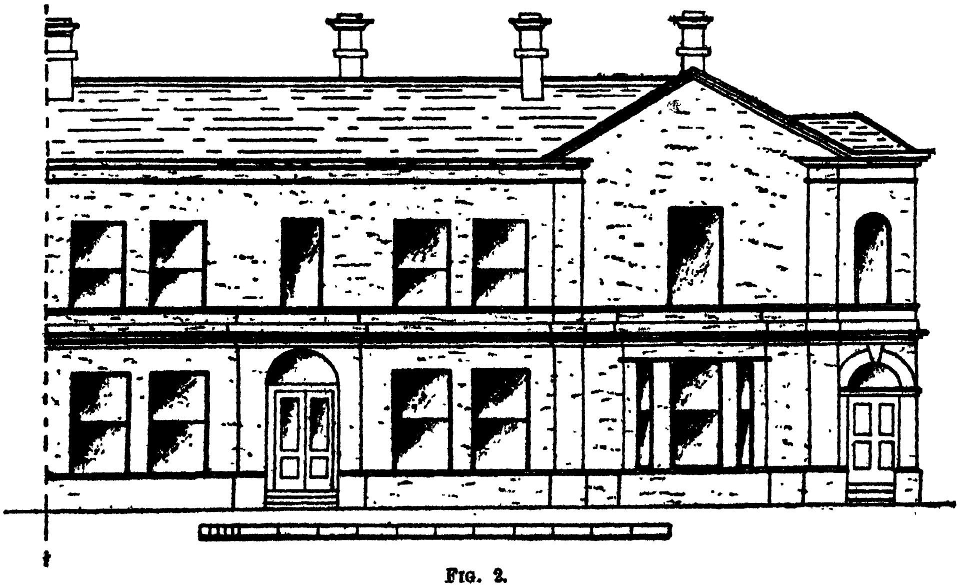
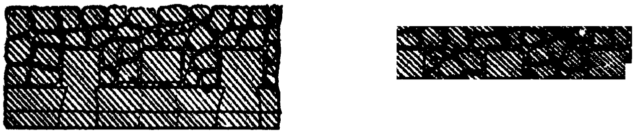


FIG. 2.

THE STONE MASON.



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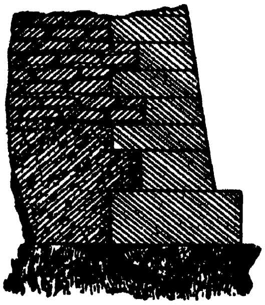

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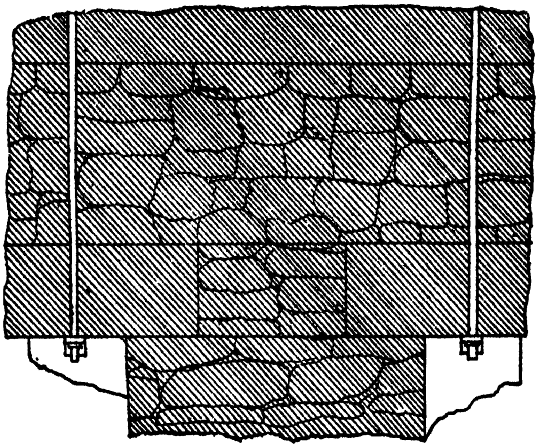

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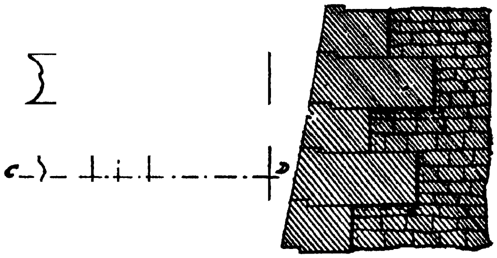

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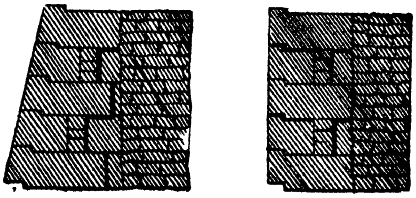

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FIG. 6.

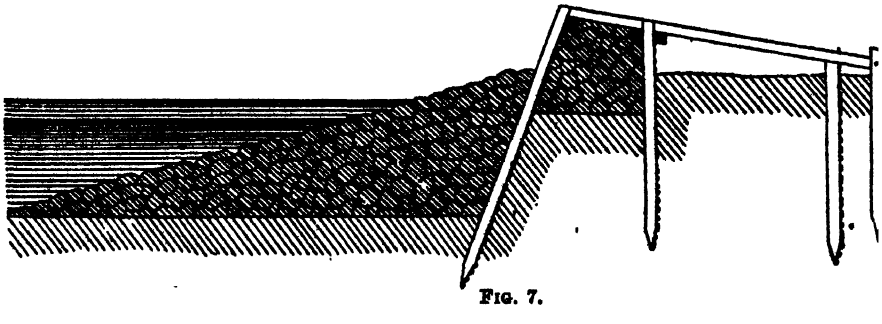
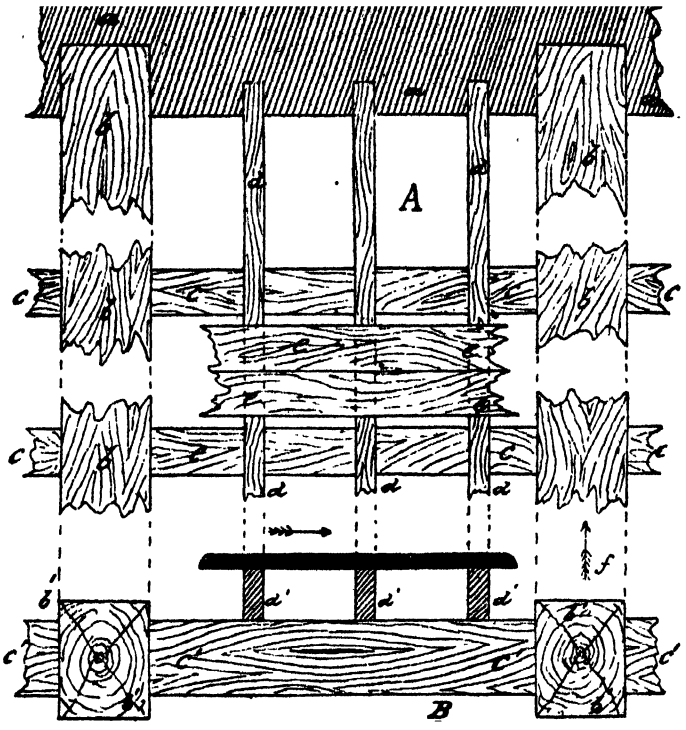


FIG. 7.

THE CARPENTER.



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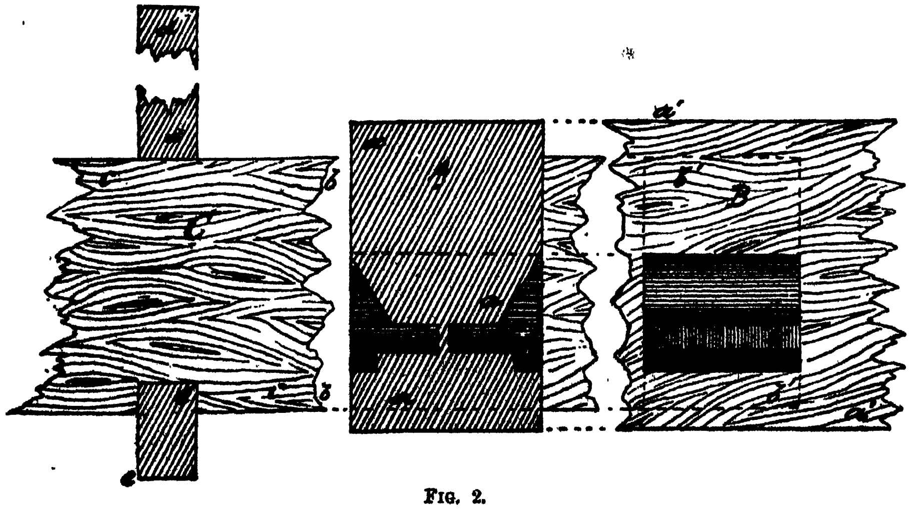
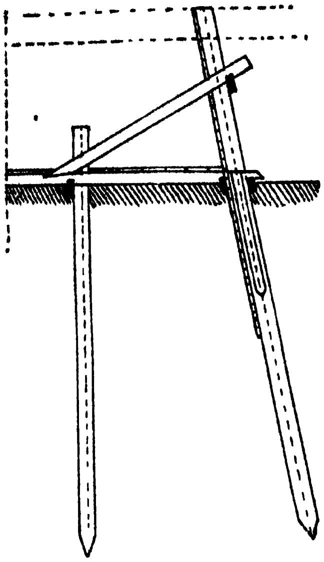


FIG. 2.

THE "CARPENTER" AND "THE STONE MASON."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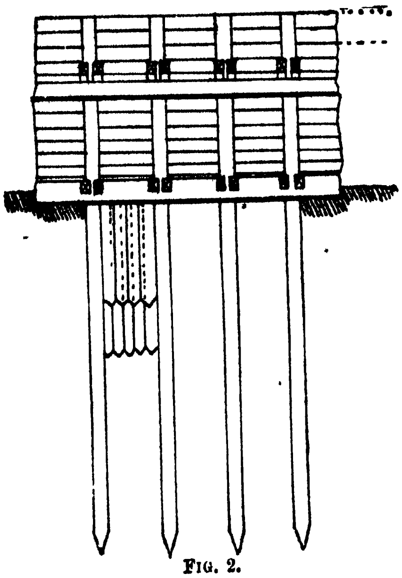
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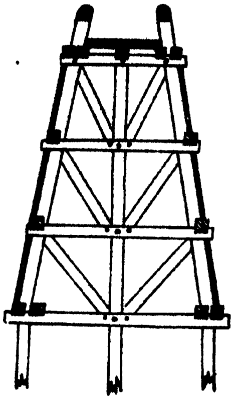
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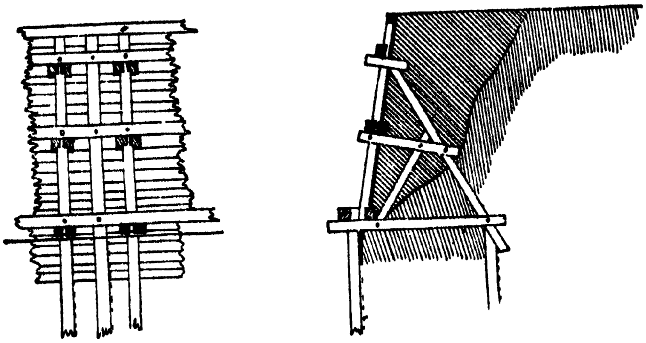
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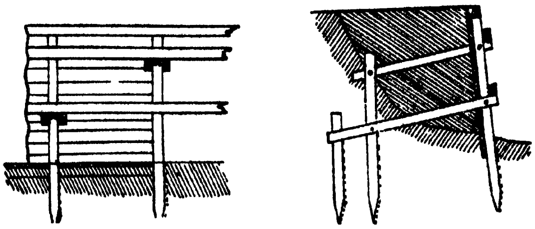
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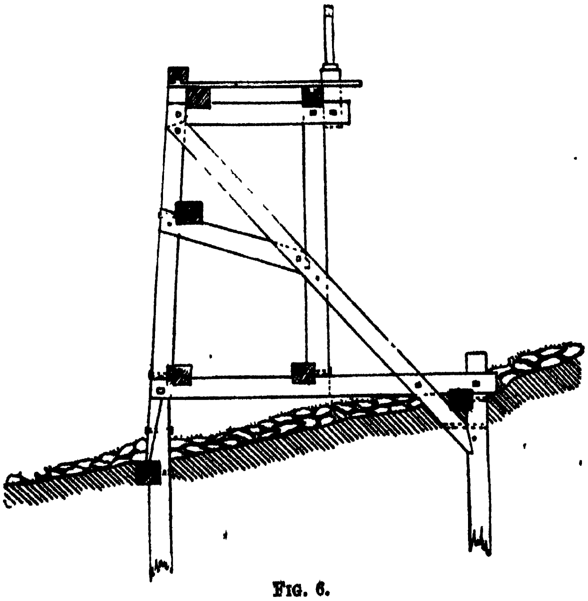
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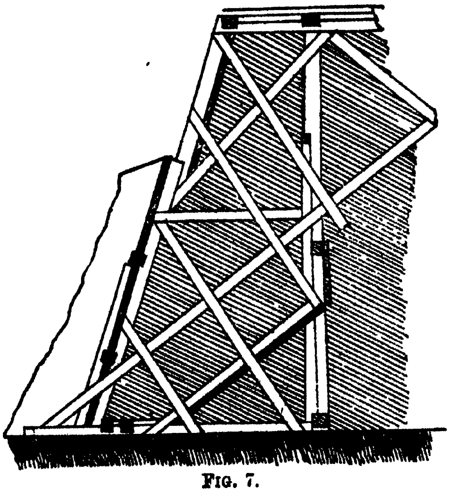
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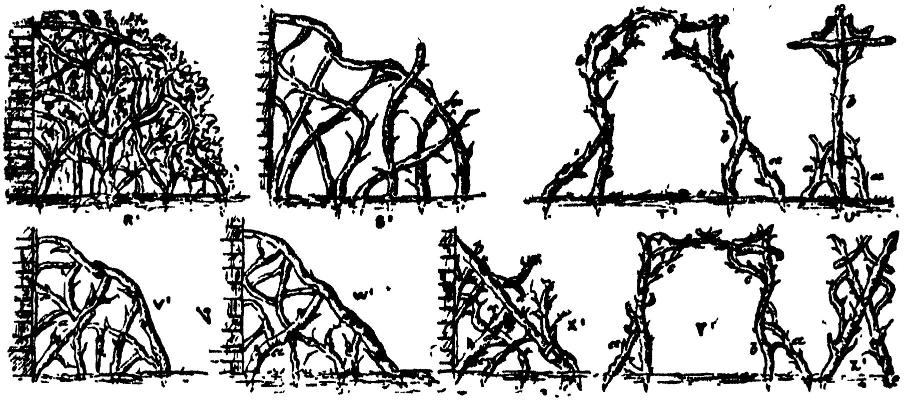

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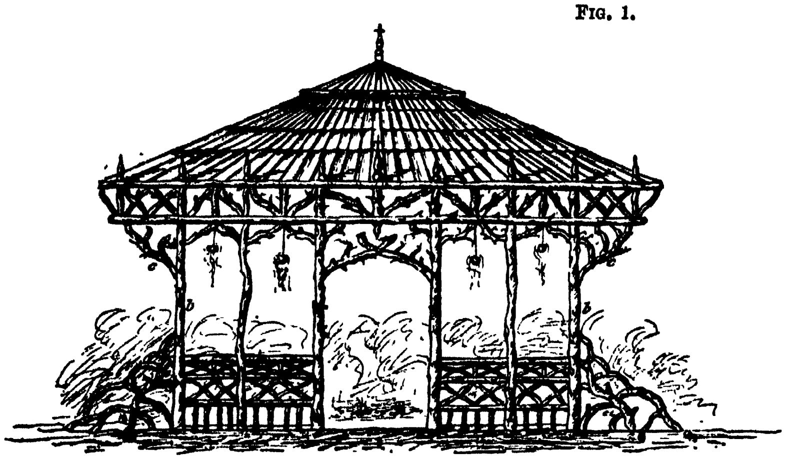

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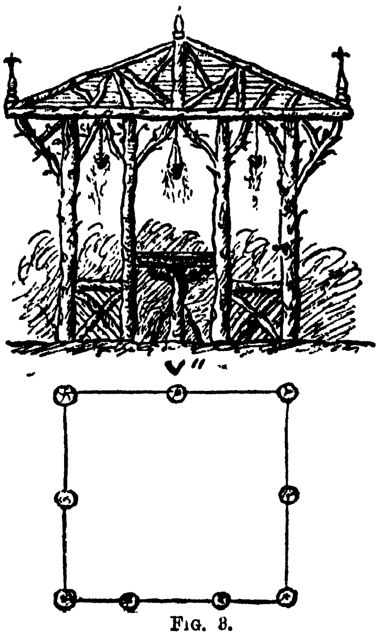

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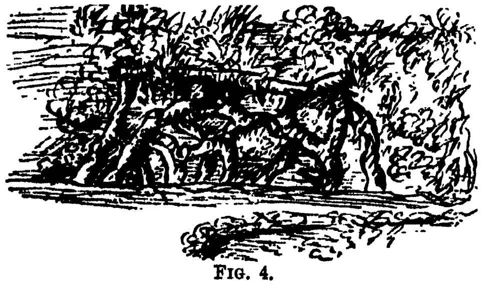

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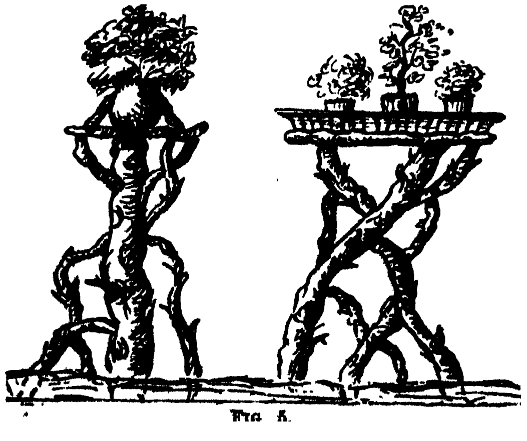

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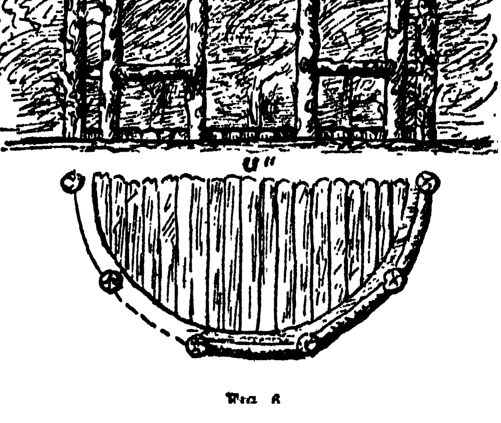
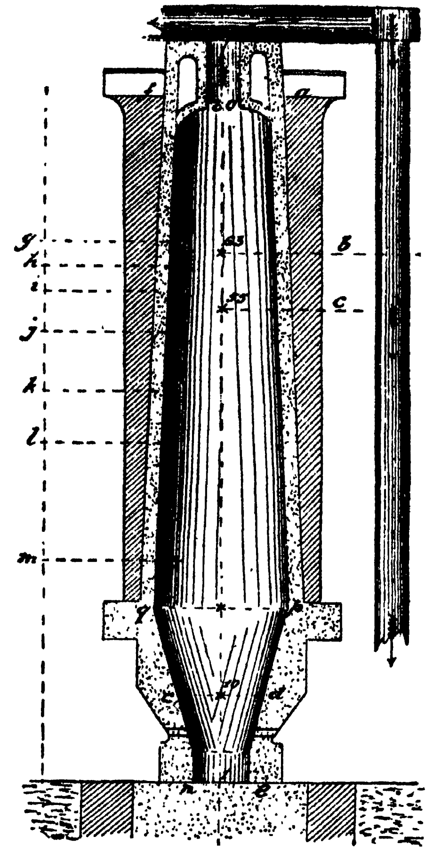


Fig. 6.

THE IRON MAKER (*see Text*).



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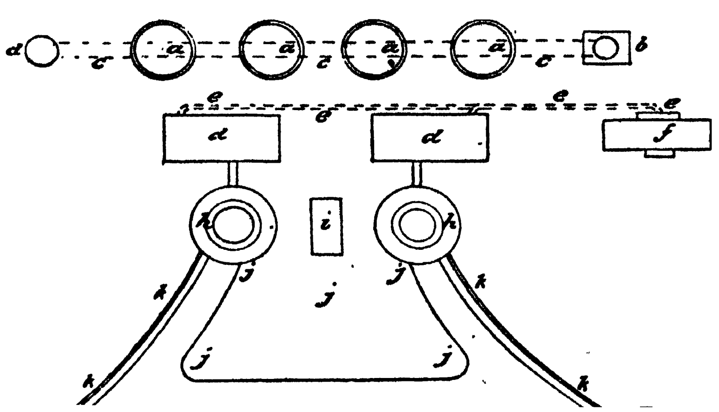

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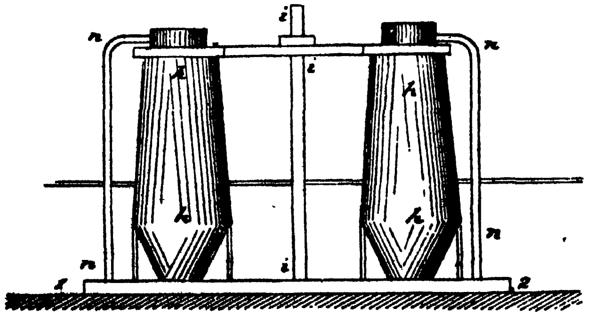

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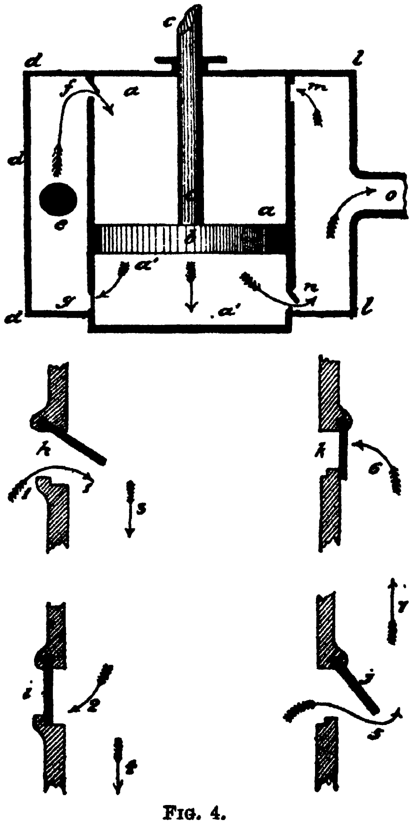

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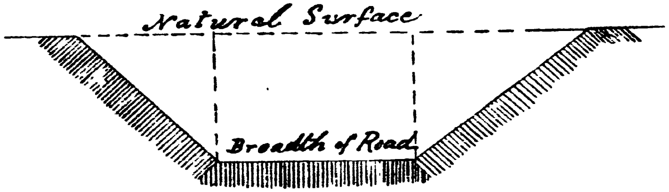

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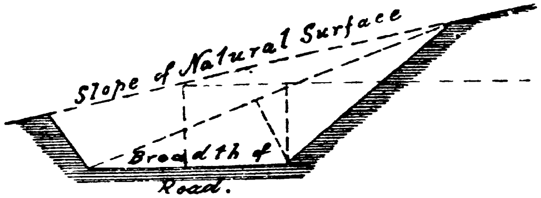

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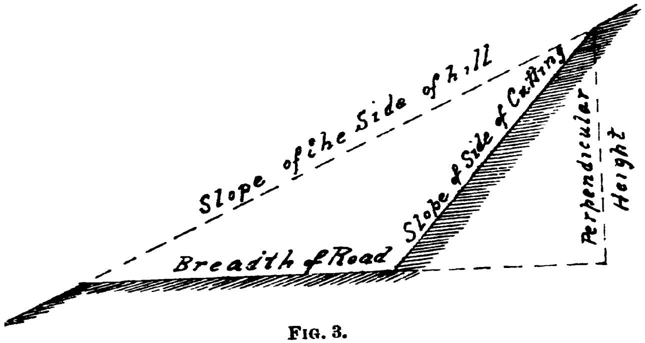

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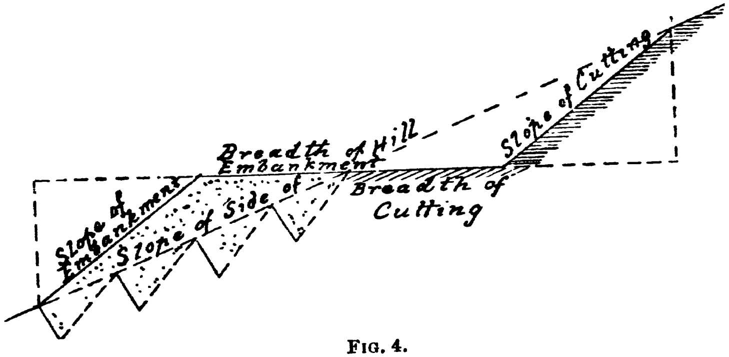

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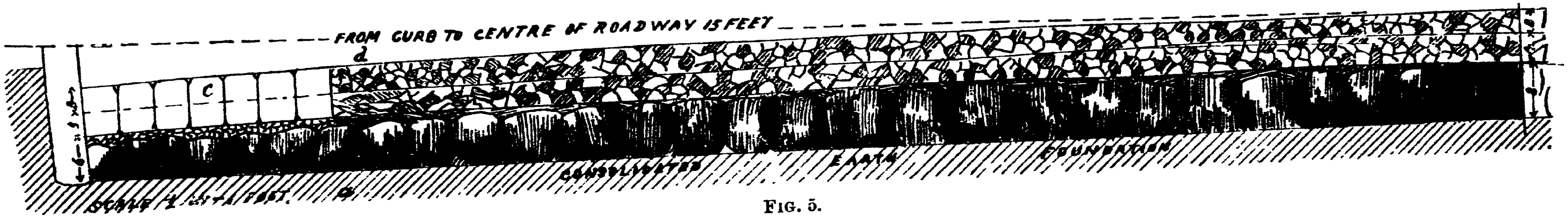


FIG. 5.

[Plate CLXVIII.

THE TECHNICAL STUDENT'S INTRODUCTION TO THE GENERAL PRINCIPLES OF MECHANICS.

LAWS AFFECTING NATURAL PHENOMENA—MATTER AND MOTION.

CHAPTER XIX.

The same principle named at end of last chapter as exemplified in the loosening of fast-bound nuts of screw bolts is exemplified in the simple process of releasing the glass stopper of a bottle which has got "fast" in the "neck." By applying heat—more than one way may suggest itself to the student of doing this—to the outside of the neck, if all round it, the glass of this part will expand, and this considerably before the stopper itself feels the influence of the heat, and expanding, will force itself, so to say, from the surface of the stopper, which will then be loosened. If we suppose that the stopper was at the same time cooled below its normal temperature, it would contract, and the contraction proceeding along with the expansion of the neck would make the operation of releasing the fast stopper the more quickly done. The reader, as he advances in the practice of his art, will find its principle as exemplified in this simple case still more practically so as regards the phenomena of contraction and expansion. In the case of the bar or rod of iron above cited, and, indeed, in all bodies in the ordinary condition in which they exist, the forces of attraction and repulsion may be considered as exactly counteracting each other, so that there is a balance maintained between them. And it is only by changing this normal condition that the balance is destroyed, and according to the character of the change, we give to the one force a greater power than the other.

Dilatation—Expansion of Bodies.

This we have exemplified in the case of the bar first heated and then altered to cool—the heat giving the repulsion or the acting power, its withdrawal making the contracting. The term dilatation is derived directly from the French verb *dilater*, and this from two Latin words, *dis*, and *latus*, wide. Dilatation may therefore be defined as the expansion of a body through the "widening" of the spaces between its particles or molecules. And a further light on this, and the cause of the condition, may be gathered from the fact that the term *latus*, wide, is the past participle of the verb *ferre*, to carry—the widening effect being the carrying of the heat to the particles of the body. The word "expansion," which we have said is practically a popular one for dilatation, is derived directly from the Latin verb *expandere*, and this from *ex*, from, and *pandere*, to spread out; so that expansion means that condition of a body in which the particles are spread out from each other. "Contraction," which is the converse or opposite condition to expansion, is derived directly from the French *contracter*, and this is derived from the Latin words *con*, with, and *trahere*, to draw or pull. So that the term means that a body is in that condition in which the particles are drawn or pulled close together with a certain force, which in the instances above named is the reduction of the temperature of a body, or the lessening of that heat which was before present in it. In the preceding paragraph we have given a few illustrations of the way in which the contraction and repulsion of bodies are exemplified in mechanical work. Simple as these illustrations were, they contain the germ, as it were, of a wide range of facts in connection with the practical work of the mechanic. It may, indeed, be questioned whether there be any more important branch of mechanics than that illustrating the laws of contraction and expansion. Those in one sense may be said to be convertible terms—at least, in practice they are frequently so; in some structures which are wholly metallic, and which are therefore good heat conductors, and because so good "receivers," as wide as good "dispensers" or givers-out of heat, the two conditions of contraction and expansion are continually interchanging. So much so that it is the literal truth that there is no metallic structure, be it the framework, say of a machine, or of a bridge, of which it can be said that it is at any time at rest. There is, on the contrary, a continuous movement, but varying both in direction and in extent according to the variations of temperature, which practically is never at any stated degree. And by delicate adjustment of apparatus the structure could be made to register or record all its movements and their amount. It is thus difficult to say in what part of a machine, or what is called a stable structure, some of the phenomena of contraction and expansion may not be operating to bring about a change which may be more or less disastrous to its life or working capacity. It is therefore the duty of the mechanic to be careful that he so designs the parts and so arranges the details of the construction of the machines he deals with, that those characteristics of the materials he uses which we are now treating of may be prevented from so displaying themselves as to bring about what every mechanic in large practice knows but too well the danger and the costly nature of—namely "break-downs."

Centre of Gravity.

Before proceeding to place before the youthful reader various points connected with the motion of bodies which have a direct and special bearing on certain principles affecting mechanical work, such as the way in which motion is modified by changes in the shape or form of the moving bodies, etc., etc., it will be as well to take up at this point the subjects of "Centres of Gravity" and "Specific Gravity." And first as to the "Centre of Gravity." If the young reader has carefully read—which, according to the views enunciated in the papers in this work given under the head of "The Technical Workman as a Student: How to Study and what to Study," is a term equivalent to carefully considered or studied—what we have written on this subject, he will have no difficulty in understanding this statement. In every body, no matter how bulky (see "Bulk" in a preceding paragraph) or massive or large, and no matter how great its weight (see "Weight")—that is, however heavy, and whatever may be its shape, figure, form or configuration, there is a point in it in which that weight is, so to say, concentrated, and which has a precise and definite relation, and one uniformly maintained so long as its weight and shape remain unaltered, which, if acted upon by a force, or upon which if power or energy be exerted, will influence the whole mass of that body. (See "Mass," in a preceding paragraph.) This is equivalent to saying that, if a body or mass of material be at rest, and a force or power be applied to this particular or definite point calculated to put that point in motion, the whole body or mass will be put in motion. The converse of this is also, and must be, equally true: that if the body or mass be already, or supposed to be already, in motion, then, if a force be applied at that point sufficiently powerful to stop or arrest the motion of this particular definitive point in the mass or body, the motion of the whole body or mass will be arrested. If the young reader will think over what is involved in these statements, he will perceive that they come to the same thing as saying, or they mean, that the mass or series of molecules of which the body is composed has those molecules so disposed that they must be distributed equally all round—to use a familiar phrase which gives a clear idea of what is meant—that point. In other words, that there will be no greater number of molecules, or no greater weight of materials, at any one side of the body than at another; and this will be true at all parts of the body. This will enable the young reader to see clearly, what he might not have done on first consideration of the subject, that this "point," in all bodies, must be, to use the popular and easily understood phrase, central to those bodies—which is but another way of stating that this definite point we have so far been considering as present in every body, is its "centre." This term is derived from the Latin word *centrum*, and this again comes from the Greek *kentrin*, to prick, as with a needle, or make a point; just as one would, in making the central point or centre of a circle, prick off a point with a needle or sharp point of the leg of the compasses with which he described the circle; and this he would say, and say truly, was the "centre" of the circle. This illustration, referring, as it does, to surface only, the young reader may easily understand; but it may not appear to him so apposite, or easily comprehended, in the case of a solid body, such as a globe or sphere, or, to give it its familiar name, a ball. But if he will think it over a little, he will see that the "point" we have been explaining as belonging to all bodies must, in the case of a ball or globe, be in that portion in which the mass of molecules at all positions are equally distant from it; so that, to give a graphic illustration of the point, if any part, as *a*, be taken distant from *b* (see fig. 6), the mass *e* will be at a distance from it of the same length, just as *c*, *d*, and *e* are equally distant from *b*. This point *b* is the centre of the ball; and, if the young reader will consider it, he will see that if the ball were somehow or another suspended from that point *b*, it would be said to be balanced. The same holds true of any solid body, whatever its shape may be: equally true of a cube, of which all the sides are equal, as *e f g h i j* in fig. 6, the centre of this being a point in which the lines passing through the points *k*, *l*, *m*, of the sides would intersect each other within the body or mass of the cube.

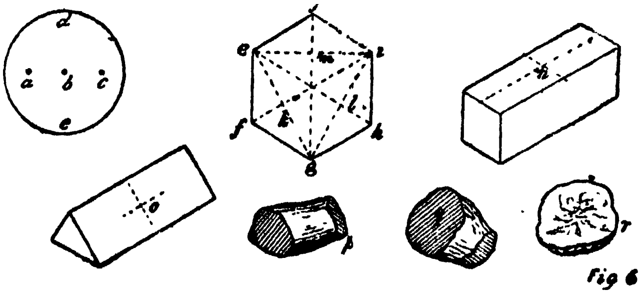


Fig. 6.

It is obviously more easy to decide where this central point is in the case of a regular body, such as the globe or the cube, or as in the prisms, rectangular as at *n*, or triangular as at *o*, than it is in the case of bodies or masses such as *q* and *r*, which do not assume the form of any of the bodies known as the geometrical or regular solids. But such bodies, however irregular, have also their central or balancing points. The young reader may have some difficulty in comprehending how such solid bodies as we have shown in fig. 6 can be balanced, so to say, upon, or be suspended from, the central point, which is *within* the mass. But he will more readily understand the point under consideration if he take the case of a thin flat board, of which *a b* in fig. 7 represents the flat or upper side, and *c d* the edge. By drawing lines to the opposite corners, the point *e* of their intersection will be the point on which, if the board be placed on a sharp-pointed support, *f*, it will be found to be balanced in all positions it may be made to assume. This balancing point will only, however, be in the position at *e* if the board be of equal thickness throughout its whole length, and be made of wood equally heavy throughout. If the end *e b* is through any cause heavier than the end *e a*, then the balancing point *e* will have to be moved nearer the end, say to *g*, before it can be balanced, as at *h*, in the same way as it was balanced on the point *e* at *f*. And if the young experimenter, with a board, as *a b*, having its end *e b* heavier than the end *e a*, assumed that the point *e* at the intersection of the diagonals was the centre of balancing, on attempting to support it on the needle-point *f*, he would find that he would not succeed. For although it is true that the point *e* is a centre, it is only the centre of the *surface* of the board *a b*, with the end *e b* heavier than end *e a*; it is not the centre of the *weight* of the body, which alone is the point which we for the present call its balancing point. The principle here involved is that it is not the circumstance or quality of the "dimensions" of a body or mass which decides the position of this central or balancing point, but that of the "weight"—or, as the popular phrase is, its heaviness—only. As this principle is of importance, we further illustrate it by simple diagrams in fig. 7, in which *i* is the centre of the surface of the same board, *j k l m* being the point of intersection of the diagonals *m k*, *j l*. If the board be of equal thickness, and the wood also homogeneous throughout, then this centre of dimension will be the balancing point, as shown at *n*. But if the side *k l* of the square board be heavier than *m j*, as by having a sheet of lead or another piece of wood fastened to it; or if the side *k l* be thicker, as at *o*, than *j m*, then, while the "centre of surface" or of "dimension" remains as before—this being always definite with the definite shape—the centre or balancing point will be changed, as at *o*. The same holds true of any form—say of a circular board, the centre of dimension or surface of which is obviously the centre of the circle. And this will be also the "centre of balancing" or "centre of weight," if the circular board be of equal thickness and density throughout, as at *q*; but if the disc or board be weighted, as at *r*, or be made thicker, as at *s*, then the centre of weight, or balancing point, will be different from that of the centre of surface or dimension.

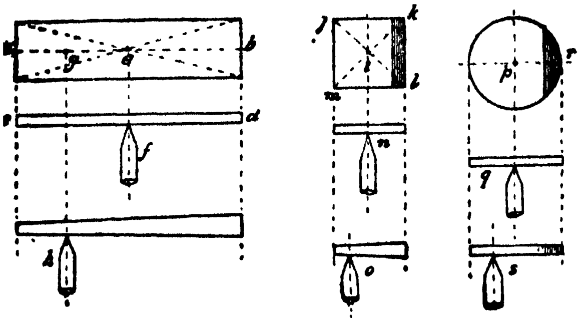


Fig. 7.

Further Points connected with the Centre of Gravity or Centre of Weight, or the Balancing or Central Point of Bodies or Masses.

In the preceding paragraph we have illustrated the method of finding the balancing point of regularly-shaped bodies: in now showing how irregularly-shaped bodies can have their balancing or central points obtained, further points connected with what, in the principles of mechanics, is called the "centre of gravity," will be explained. Let *a b c d*, fig. 8, be the body with an irregular outline. Let *e f* be a plumb line or plummet, which can be simply made by securing some heavy body, as a piece of lead (see the "Dissertation to the Technical Dictionary," forming part of this work, for derivation of plummet or plumb line), to the end of a piece of cord; or, if the body be small and light enough, hold it in the one hand, keeping the extremity of the cord of the plummet firmly fixed at any point, *e*, near the outer edge; and allowing the plummet *f* to hang freely. Draw a line lightly along the cord *e g*, so as to mark accurately its position across the surface of the body. Change now the position of this, and suspend it, as before, with the extremity of the cord held at some other point, as *g*, allowing the plummet *i* to hang freely. Then mark the position of the plummet line *g h* across the surface of the body. This will now have two lines, as *n l*, *k m*, on its surface, intersecting in the point *o*. This is the balancing point of the body *a b c d*. In like manner the point *p* is found for the irregular body *q r*. Any weight, as *t* in fig. 8, suspended by a flexible cord, *u v*, and allowed to hang freely, always hangs vertically—that is, the line of suspension, as *u v*, is always a true perpendicular to the horizon, represented by the horizontal line *x y*. Hence "plumb" or "plummet lines" and "vertical lines" are synonymous, meaning precisely the same thing. And the mechanic's plumb line is the means of finding truly vertical lines—that is, perpendicular to the horizon or ground level; and what is called the "mason's level" is simply a frame in which a small plummet is suspended, by which he knows when his wall or other surface is level—that is, parallel to the horizon or at right angles to a plumb or vertical line

—from the circumstance that when the base of his appliance is placed or rests upon the horizontal or truly level wall surface, the plummet hangs vertically. From what has been said on the subject of the "attraction of gravitation"—or, as it is more simply called, "gravitation"—in preceding paragraphs of the present paper, the young reader knows that if a body be suspended at some distance from the ground level and allowed to drop, as the plumb *t* in fig. 8 would drop if the cord *u v* were suddenly cut, it will fall towards the ground, and this in a vertical or plumb line, which, if continued indefinitely, would pass through the centre of the earth, which is virtually the centre of the attraction of gravitation, so called. From this tendency in a body to fall or gravitate—which, popularly phrased. is in virtue of its weight or gravity—it follows that if the body, as at *t*, fig. 8, be prevented from falling till it reaches the final point of all falls, drops, or descents (namely, the earth's surface, or some body resting on this), and this because of its being suspended, as, say, by the cord *u v*, the body, *w*, must always be below the point of suspension; and the centre of balancing, as *v* in fig. 8, must be a point on a line passing vertically from the point of suspension, *u*, which, if continued indefinitely, would pass through the centre of the earth: in other words, the line, as *u v*, would be vertical, as a plumb line, or at right angles to the horizon. All circles—and the periphery of a globe is a circle—are polygons made up of an infinite number of short straight lines. Any long flat body resting on the surface of a small globe may touch it apparently at one point; if the globe be larger it will rest upon more than one point or part of the surface; and if the globe be very large the flat body will seem to rest upon a very extended part of the surface of the globe—as if that surface were flat, like the body resting on it. Now, our globe is of dimensions so enormous, as compared with any structure which man builds or erects upon it, that to all practical purposes it is a dead level—so that all lines or surfaces parallel to it are called "level" lines—which means that they are horizontal, as being parallel to or coincident with the horizon, which is a line supposed to stretch right across the visible circle of the heavens at the level of the surface of the earth or globe. These points now given, the youthful reader will see as we proceed, have a very practical bearing upon stability in construction of all kinds—in other words, on security in all the structures which man erects or builds. And they arise from the tendency which all bodies have to fall to the surface of the earth—that is, to pass through a space between what is called popularly a high and a low level—if allowed to fall or drop. And, as we have seen, all bodies are dominated, so to say, by a central point, which we have hitherto called a balancing point, or centre of weight, and which last expression is equivalent to the one generally used—the "centre of gravity." And we have seen that this centre varies in position in relation to the mass or bulk of the body; and it is again on the relation this "centre of gravity" or "balancing point" of bodies bears to the earth's surface, or any surface on which the bodies rest, that their stability or security depends.

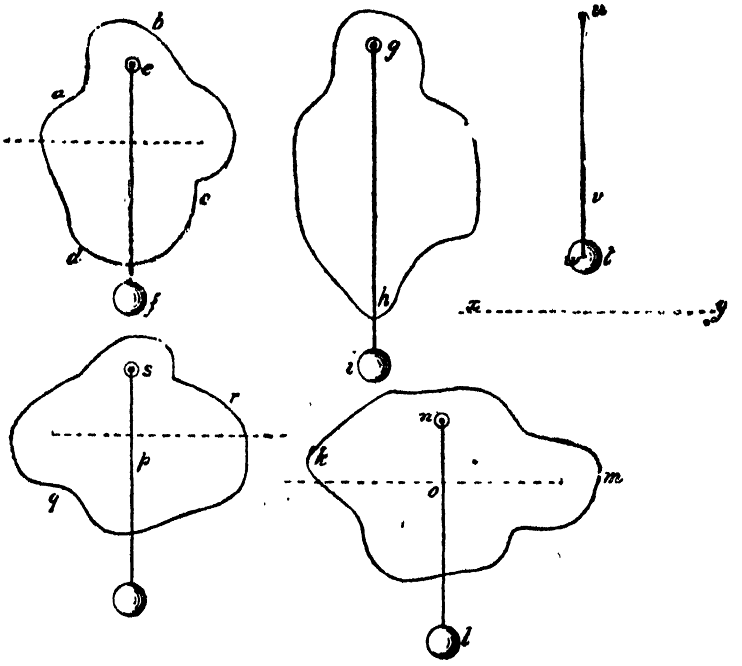


Fig. 8.

THE GRAZIER AND CATTLE BREEDER AND FEEDER.

The Technical Points connected with the Varieties or Breeds of Cattle—Their Breeding, Rearing, Feeding, and General Management for the Production of Butchers' Meat and of Dairy Produce.

CHAPTER XV.

At the end of the last chapter we named the constituents of food known as "non-nitrogenous." These substances are gum, pectin, sugar, starch, and fat, and they also find their representatives in the constituents of the animal frame. These non-nitrogenised substances go to keep up the warmth of the animal by promoting respiration, and add to the fat of the animal. They have thus had the name given to them of "heat-givers," of "respiratory compounds," and of "carbonaceous constituents." The last name is indicative of what Dr. Lankester, an able expounder of the chemistry of food, has called them—namely, the food which keeps up the animal heat. This heat is represented by a normal temperature of 90° Fahr.

The constituents of the ash of plants, useful in food, are chiefly the lime and the phosphoric acid which supply the constituents of the bone; the salts of potash, which help to keep up the juices; and the phosphate of soda, the blood of the mineral frame. Dr. Voelcker, the distinguished Professor of Agricultural Chemistry, and the consulting chemist of the Royal Agricultural Society of England, thus summarises the two classes of nitrogenous and non-nitrogenous substances of plants:—

"Nitrogenous substances: vegetable albumen, a substance identical in composition with the white of egg. Vegetable fibrin or gluten: a compound occurring in considerable quantity in wheat, and giving elasticity to the dough made with wheaten flour. Vegetable casein: a substance identical in composition with the curd of milk. Legumen: a peculiar vegetable principle, which derives its name from its occurrence in large quantities in peas, beans, and leguminous seeds. Non-nitrogenous compounds: all oily and fatty matters, starch, which constitute the principal part of wheaten flour, oat and barley meal, rice, Indian corn, and the dry matter of potatoes. Sugar—which abounds in mangolds, carrots and turnips. Gum and mucilage—constituents of every kind of food. Pectin: the jelly-like substance which is found in carrots, mangolds, turnips, and many other bulbous roots. Cellular and woody fibre: substances which constitute chiefly the bulk of straw and hay, and occur abundantly in every other vegetable produce."

The ashes or inorganic constituents of plants are of the utmost value in the feeding of animals, although the popular notion of vegetable substances points to the conclusion that what are called minerals form no part of them—incapable of decay or combustion. On the other hand, in relation to the flesh and the blood of animals, the popular notion is precisely in the same direction, and that they, like the vegetables, if left to decay, or if consumed, would totally disappear, leaving nothing behind. Yet we find the blood of grass-eating or herbivorous animals, as the cow or the horse, rich in alkaline carbonates and in chloride of sodium or common salt; and those carbonates and this salt we find largely present in the grass and the green crops they eat. Apart from their mineral constituents or ash, the organic part of plants, that is the part which can decay or be burned completely away, is of not the slightest value as food for animals. If we can conceive of some method of depriving them of their mineral constituents, the grasses in pasture, the hays made from meadow grasses and clover, or the turnips or other roots used now by animals, would be intuitively rejected by them as utterly valueless as food. There are some food substances in which certain constituents are lacking (such as the white of eggs, which is purely albuminous), and which are therefore valueless in the production of blood; so that an animal would literally starve if fed solely upon this—if indeed an animal could be got to partake of it after the first or the first few trials, as he would intuitively feel that there was no use, so to say, in feeding on, or rather taking it, for feeding would be impossible.

Substances, therefore, to be useful as a food, must contain all the principles or constituents necessary to maintain and support life, by supplying all the elements of the body. And just as we have seen that there are certain substances in which certain constituents are wholly absent, so we find that while there are others in which are found the constituents required to make them nutritive or life-supporting, so that an animal would not actually starve while eating them, still those nutritive constituents are so unequally distributed, and some are so sparsely or slightly present, that the animals using them would not, however, thrive, or at least would not fatten. It is this inequality in the amount or percentage of nutritive constituents in food substances which creates the difference in their feeding value. And it is this circumstance which leads the farmer or stock breeder to look out for and give to his animals those feeding substances which are most nutritive, or certain constituents which will keep them in the best health while they will continue to improve in condition. And in doing this his own experience is greatly aided by the likes and dislikes in the way of feeding which his animals display. This may be called the art of farm-stock feeding. We have seen how all food substances are made up or composed of a variety of constituents, all of which go to make up their nutritive value, and that those constituents vary in different plants; the farmer or stock breeder, aided by the researches and the results of the investigations made by the agricultural chemist, endeavours so to arrange his feeding systems that he will in the foods which constitute them secure the maximum of feeding results with the minimum of cost. This constitutes the science of farm-stock feeding. To the details of this, the art and science of cattle or stock breeding, and of the various foods and feeding substances which are at the command of the farmer, we now proceed.

In the general statement of the theory of cattle foods and feeding which we have now given, the reader will have perceived that in the classification of the constituents of foods two divisions are marked off, having what appear to be very clear and sharply defined limits, separating the one from the other. Stated generally, those are the albuminous, nitrogenous, or protein, and the carbonaceous or non-nitrogenous compounds; the first of these classes being otherwise known as "flesh forming," the second as "fat producing" or respiratory elements. When the celebrated German chemist Von Justus Liebig propounded his theory of food and feeding, on which the modern science of farm-stock feeding is based, such was the accuracy of the chemical investigations and analyses upon which the theory was based, and such the style of argument which that ablest of modern chemists and most graceful of scientific writers adopted, that the agricultural world almost universally came to the conclusion that a new era of agricultural progress was opened up, in which the practice would be so definite and precise in all its details, that with certain given means, a certain end could be reached; thus raising farming to the position of a fixed science, in which with certain factors certain results would be obtained in all its calculations. Hence the expectations raised in the minds of so many by the expositions of Liebig as to what the science of agriculture as expounded by him would do for their practice were of the most vague and extravagant character. And this led, of necessity, to a painful reaction when the stern facts of practice, modifying materially the indications of theory, came to the front and asserted their power, so that from thinking too highly of what agricultural science could do for the farmer, in that it could do all he wished, the agricultural mind decided that it could do nothing. But as calmer and juster views of the whole subject gained ground, it was seen that while the new science could not do all for the farmer in his practice, it could do a vast deal. And time has proved the accuracy of this view; and it is now admitted on all hands that to Liebig and his theory of cattle food and feeding, as part of his general system of agricultural science, modern farming is under the greatest of obligations.

While the accuracy of the chemical investigations made by Liebig was never called in question, there is now no doubt that he erred—and in so doing did the true value of his system much injury—in applying his theory too rigidly, forgetful that the circumstances of daily practice possessed modifying influences of great powers. Thus, in assigning to certain constituents in food the duty of forming flesh only, and to others that of producing fat only, there is no doubt that Liebig erred. So also in determining the values of the different constituents, considering them in his calculations as definite factors giving definite results. In both cases he erred in considering the subject wholly from a chemical point of view, forgetful of the fact that it is largely influenced by physiological considerations. For, as has been well remarked, animals are not like the test tubes and apparatus used by chemists in their analyses—in which if certain substances are placed certain combinations are formed. These combinations under such circumstances are known with definite and absolute precision, and can be so stated in the terms of an analysis of each; but not so in the case of an animal. As we have pointed out while treating of soils and manures in an earlier part of this paper, a great variety of circumstances come into play, very materially modifying the results of the calculations of the agricultural chemist—often, indeed, leading to results totally unexpected and unlooked for. So in the case of dealing with animals, a still greater variety of unknown elements come into play, and this simply because we have now the higher and more mysterious element of animal *life* to deal with. Hence it is that although the chemist can by his analysis tell us that a food to be used for cattle is composed of such and such elements, and that therefore certain feeding or fattening results will be obtained by its use, it by no means follows that these results will be secured when we give them to the animal. To say that certain constituents would certainly go to the formation of fat, while others would as certainly go to the production of flesh, was going quite beyond the province of the chemist, and indeed, for the matter of that, outside the domain of the man of science,—for science knows nothing, or should know nothing, of assumption, it deals only with facts, concerns itself only with the known. Now, all this marking or ticketing off, so to call it, of the different constituents of food, this one being allotted to the task of producing one element, this another, was based only on assumption. For the points stated as actually existing could only be assumed to exist, it being, of course, utterly impossible to trace the processes through which the constituents went, within the body of the animal.

THE YOUNG ARCHITECT OR ENGINEER.

His Studies—Office Duties—and Practical Work in the Preparation of Working Drawings, of Specifications, and Contracts for Work.

CHAPTER IX.

Corporation or Local Board Drawings (*continued*).

Generally the originals are submitted and signed by the chairman, and duplicates permanently left with the authority. Plans, elevations and sections are required—occasionally only plans and sections. No definite instructions can be given to the young architect, as the regulations differ in every district; but the following notes may be found useful. It is not usual to interfere with the design of the exterior, except in the special cases of a few important thoroughfares in the largest towns, laid out at great public cost, when an approximate uniformity of height and of materials may be insisted on; the projection of cornices, oriel windows, or other architectural features, is generally limited by a bye-law; as well as the height of buildings in narrow streets, which is occasionally limited to two stories above the ground level in streets less than thirty-six feet wide, or the height is not allowed to exceed the width of the street in front measured at right angles to its general direction. (1) The sections must generally show the depth, level and nature of the proposed foundations, the depth, fall and size of the drains, and their connection with the nearest sewer, the depths being indicated by reference to some near fixed point or ordnance datum. (2) The heights of the various floors, which in many districts may not be less than a given minimum, especially those intended for domestic purposes—which, if not attics, must be nine feet in clear height in every part at the least, and every attic or room extending partly into the roof must be seven feet six inches or eight feet in height at least from the floor over one-third or one-half the superficial area of the room. (3) The sections of the floors and roofs must show the gutters and drainpipes, also figured dimensions of the bearing timbers—certain minimum strengths for

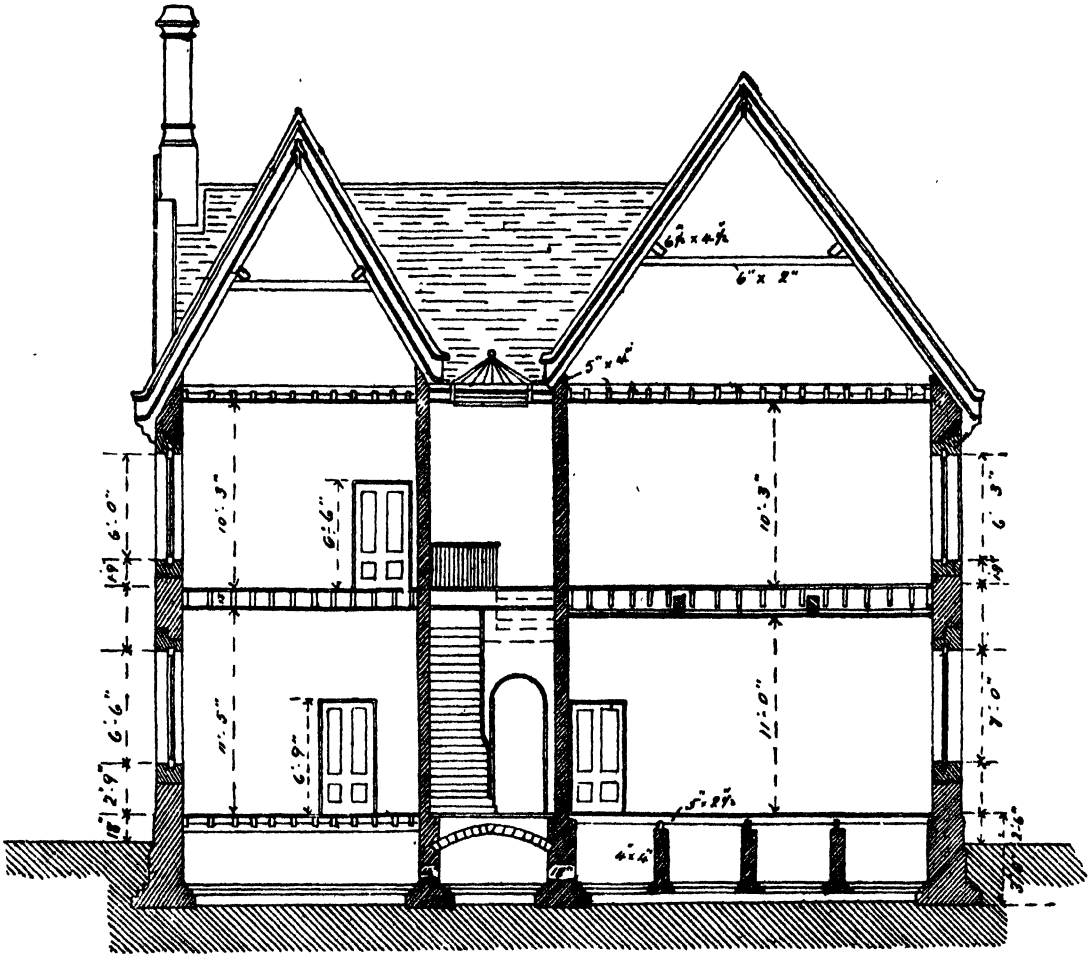


Fig. 8.

bearings of stated lengths being frequently insisted on. The level of the ground floor of every dwelling-house not used as a shop or place of business must be at least six inches above the level of the edge of the footway or street. (4) The thickness of the external and internal walls: in some districts an external wall one brick in thickness, or an internal wall half a brick in thickness, may not exceed thirty feet in clear height. The plans must generally provide a certain minimum superficial area of open yard space—in some towns 70 superficial feet being considered sufficient, in others 250 are required. The privy and ashpit must be planned in accordance with certain regulations, and must be so placed as to be readily accessible from a back passage, the width of which is also regulated by a bye-law—generally five or six feet. There must generally be a given distance between the walls of the dwelling and the privy.

The plans must also show walls between adjacent houses of a given thickness, which must in some cases be carried above the line of the roof, and finished with a stone coping, in others finishing flush with the under-side of the slates. Flues and chimney-breasts must be of substantial construction, and no timber is allowed to be shown on the plan within four-and-a-half inches of the interior of any flue or chimney. There are, in addition to the above, an immense and varied number of other regulations, a few only of which can be referred to.

Stringent regulations are generally laid down with reference to the construction and size of the drains; in many districts they must be kept open until they have been examined and approved of by an inspector, the connections with the sewers not being generally allowed to be made by private contractors. Certain means of ventilating the drains must be provided—generally by connecting them with the down-spouts, or (what is undoubtedly better) by a special pipe or shaft carried to a stated height above the eaves. Every room intended to be used as a dwelling or sleeping room, with the exception of attics, must have an aggregate window area of not less than a given number of square feet—generally ten clear of the sash frame —and the top of the window must be not less than seven feet six inches above the floor; to insure efficient ventilation, the upper half at least of the window must be made to open. An attic may instead of a window have a skylight of not less than six feet superficial area, of which at least one-third must be made to open. Special means of ventilating all rooms not having a fireplace must be provided, aud special regulations are generally made for the proper ventilation of public buildings. The strength and dimensions of area gratings and grids is generally regulated by a bye-law. Officers are frequently appointed to inspect works in course of erection, and empowered to prevent or report any infringement of the bye-laws: of course every facility must be given them at all reasonable hours to examine every portion of the building. No new house, addition or alteration, may be inhabited until it has been certified after official examination that it has been erected in accordance with the bye-laws. Regulations are generally made for the provision and maintenance during the erection of any building of a substantial hoarding of a given height. Written notices must generally be given for permission to take up any portion of the public street or footpath in front of the works, for the supply of water for mixing mortar, cement or concrete. With a little care and experience on the part of the young architect, no difficulty need occur in complying with the bye-laws of any local body. Those of the Metropolis are generally considered the most stringent.

Detail, or Large-Scale Drawings.

As soon as the architect has completed his contract drawings, he must commence the details: they may be divided into those that are drawn to scale, and those that are full size. Various scales are selected for the former: those most frequently used are, half-inch to the foot, one inch to the foot, and quarter-full-size, or three inches to the foot. It is of the greatest importance that the young architect should be able to prepare these drawings; the ability to do so can only be attained by long and persistent study, as there is no royal road to the ability of preparing details. There are many members of the profession who possess a certain facility in the preparation of a sketch design, which, by the aid of a foreground and sky, may be made into an attractive drawing, but who are quite incapable of preparing the equally important drawings required to enable the contractor and his men to translate the design into brick and stone. The knowledge that has to be acquired to enable the architect to prepare detail drawings is, firstly, a thorough knowledge of the work of, and the materials used by, the various trades which are successively engaged on every building whilst it is in course of erection, commencing with the excavator, bricklayer, and mason, and terminating with the carpenter, joiner, slater, plumber, glazier, painter, and many others. This knowledge can only be obtained by the careful and persistent study of buildings whilst in course of erection. It must be evident to the merest tyro that a detail of moulds for a string-course, plinth, or door jamb, which would be exceedingly suitable if worked in oolitic or Yorkshire stone would be utterly useless if the material to be used were granite. Again, a thorough knowledge of the properties of the various kinds of timber used in building is absolutely necessary, as well as the scantlings or sizes in which it is generally sold by the timber merchant.

THE BUILDING AND THE MACHINE DRAUGHTSMAN.

CHAPTER XV.

In describing at end of last chapter the method of projecting a box which gave three views of it, sufficient to enable it to be made by an artificer, we stated that another view might be required of it. Thus one of its "sides" might be of greater height or depth than that of the other—as the height or length of the line *a b*, fig. 2, Plate CLVII., is greater than that of *c d*. We suppose the plan of the box to be of the dimensions as at *e f g h*; this being drawn or projected in the same way described in connection with *a b c d* in fig. 1, same plate.

Draw parallel to *f g* any line, as *i j*, and from *f* and *g* lines perpendicular to *f g*, cutting line *i j* in the points *k* and *l*. Produce these lines to *m* and *n*, and make *k m* equal to *a b*, and *l n* equal to *c d*. Join *m n*: *k m n l* is the "end elevation" of the block *e f g h*, looking in the direction of the arrow *p*. The elevation of the side *h g*, looking in the direction of the arrow *o*, is found thus:—Draw parallel to *i j*, from the points *m* and *n*, the lines *n q*, *m r*, cutting perpendiculars drawn from points *s* and *t*, the distance *s t* being equal to *h g* or *e f*. The heights *t r*, *s u*, are thus equal to *k m* or *a b*, and *t q*, *s v*, equal to *l n* or *c d*. The parts shaded with lines at right angles to each other serve to indicate the character of the projection of the elevation of the end *f g* in plan. The elevation of the side *k m* in *k m n l* is of course all in one plane, or quite flat; in the other elevation of the other side the part *v q r u* recedes from the part *s v q t*. The "side elevation," looking in the direction of the arrow *o*, can also be projected in the same way as *t s q r* in fig. 1, Plate CLVII.; but the line *x z* must be measured equal to *a b* or *k m*, in fig. 2, same Plate; and *y z* be drawn parallel to *h g* to point *y*. This side elevation is obtained directly as shown at *s t r u*.

We thus see how one projection or view more is required for the drawing of the object last described, this extra projection being a second side elevation, as *t q r u v s*, fig. 2, Plate CLVII. But as two side elevations may be thus required, so also may two plans. Thus, suppose the plan of top of the box, *a b c d*, fig. 3, Plate CLVII., to be of different dimensions from that of the bottom, as *a′ b′ c′ d′*; the general or complete plan of the box, as seen when looked down upon in the direction of the arrow *p* in fig. 1, Plate CLVII., would be as at *e f g h*, *i j k l* in fig. 3, same Plate, *e f g h* being equal to the plan of top in *a b c d*, fig. 1; *i j k l* equal to *a′ b′ c′ d′* in fig. 3, same plate. And to make the projection plan of box complete, as thus looked upon in the direction of the arrow *p*, fig. 1, the points *i g*, *j e*, *k f*, *l h* would be joined by straight lines. The reason for this will be more easily understood when we come to the projections of the other views of this object, in which the top and bottom plans are different in dimensions. Let the line *m* (fig. 3, Plate CLVII.) be the height of the box from base to top—or height "over all," as the technical phrase is—and *n* that of the lower part, up to the top line of which the box is of equal size throughout—that is, with its sides and ends square or at right angles to each other. To obtain the "projection" or view of the side of *i j k l* in the plan, proceed as before so as to obtain the lines *i o*, *l p*. Make *p q* equal in height to the line *m*, and draw *q r* parallel to *o p* or *i l*. Make *p s* equal to the line *n*, and draw *s t* parallel to *o p*. Project the points *g*, *h*, by lines parallel to *k l p*, cutting the line *q r* in the points *u*, *v*. Join *t u*, *s v*: the projection of the "side elevation," *i g h l*, of the box as seen in the direction of the arrow *p*, fig. 1, is thus produced, the lines not dotted being those which are to be inked, giving the finished drawing or view. The "end elevation" is projected in like manner by producing the lines *i l*, *j k*, *e f*, *g h*, to *w*, *x*, *y*, *z*, making *w a′*, *w b′* respectively equal to *p s*, *p q*, or to the lines *n* and *m*, and finishing as in the diagram. The lines *i g*, *j e*, *k f* and *l h* in the plan are the lines *t u*, *v s*, *y c′*, *l a′* in the side and end elevations.

Reverting to the projection given in fig. 2, Plate CLVII., in which the block or box has a top sloping to one side—that is, one side or front of the block being lower than the other, or back—we may conceive of it being so formed that it may slope at its top part on both sides, as *p q*, *p r*, from a central line *i j* in plan, or a central point *p*, as in fig. 4, Plate CLVII.

Let *a b* be the height of the highest part at the centre, and *c d* the height of the block at the sides—"up to the square" or level, as the technical term is—and let *e f g h* be the plan of the block, the line *j i* in the centre of its length representing the apex or line of meeting of the sloping sides. Parallel to *g f* draw a line *k l*, and cut this in the points *m*, *n* and *o* by the lines *f e*, *i j* and *h g*, produced and extending indefinitely beyond *k l*. Make the perpendiculars *m q*, *o r*, each equal to the height of the line *c d*; and the perpendicular *n p* equal to the line *a b*. Join *q p*, *p r*. This will give the "end elevation" of *f g*, looking in the direction of arrow *s*. The "side elevation" *f*, looking in the direction of arrow *t*, is produced by drawing from points *p* and *r*, parallel to *k l* or *m n o*, lines *p u*, *r v*, these cutting lines from ends of base line, perpendicularly to *k l*, the length of base from point *x* being equal to *h g*. But if the block had sloping ends as well as sides, and of the same height, the "plan" would be as at *y z a′ b′ c′ d*, the "side elevation" of *h g*, looking in the line of the arrow *t*, would be produced by drawing lines from the points *z* and *a'* to *f'* and *e'*, and from *c'* and *d'*—these latter being the points where the sloping ends meet the central line, as in the other plan, *i j*. These cut a line *f' e'* parallel to *a' z*, making the perpendiculars *e' j'*, *f' g'*, each equal to *a b* and *c d*. Join *g' k'*, *i' j'*. The end elevation of this, looking in the direction of the arrow *s*, will be precisely the same, and obtained in the same way as end elevation *m p o*.

But the block might have the top with sloping surfaces on both of the sides, and also at both of the ends, but these meeting in a flat space at the top, not at a sharp line as in the projections just illustrated. The plan in this case would be as at *a b c d*, fig. 31, *e f g h* being a flat space, *g c d f* being a sloping end, *c g h b* being a sloping side; the lines of junction at the corner being *g c*, *f d*, *a e* and *h b*. Let *i j* be the height up to the level of the flat space *e f g h*, and *i k l* that of the sides and ends "up to the square." Proceed as in the last diagram, fig. 4, Plate CLVII., in order to find the "side elevation" *m n o p* of side *b c*, looking in the direction of arrow 1. From this the end elevation *q r s t*, looking in direction of arrow 2, will be projected, as before, by drawing lines parallel to *a d* from the points *p n* to *y* and *r*, making *r s*, *t u*, each equal to *k l* and *i j*. Half only of the end elevation will thus be found, the centre line being at *u*; the point *t* being obtained by setting off from *y* to *t* a distance equal to *x p*, taken from the side elevation *m n o p*. The other half of end elevation is shown in dotted lines. The end elevation, looking in the direction of the arrow 2, or that at 3, may also be obtained from the plan *a b c d* directly, as well as from the side elevation, as just described. In the latter only one half of the end elevation, as *u q r t*, is obtained from the lines of the side elevation *m n o p*, and only part of the points necessary to complete this half are projected from *m n o p*—certain measurements, as *y* to *t*, having to be specially taken and applied to the end elevation—and to complete it, the part shown in full lines is to be repeated on the other side of the line *q u*, which is the centre point of the breadth of the end elevation, corresponding to *a'* in the plan at *a b c d*. The end elevation may be obtained here directly from the plan. This is shown at *b' c' d' e'* in fig. 36, the lines of which are obtained in the same way as has been already described, *c' f* being made equal to *j i*, *c' g'* to *k l*.

In the projections in figs. 2, 3 and 4, Plate CLVII., the reader, if at all acquainted with domestic architecture (see the special paper on "Houses and House Planning"), will recognise in them subjects connected with the roofs of houses, etc. Thus, in fig. 2, Plate CLVII., *k l m n* represents the end view of a house or structure, having a roof of the kind or class known as a "lean-to" roof, the front view of which is at *s t u v*. In fig. 4, Plate CLVII., we have in *m p o* the end elevation of what is called a "gabled roof," sometimes a "span" roof, *w x* being its side or front elevation. In same figure we have in *y z a' b'* the plan, and in *g' e' f' j' k'* the side elevation of that class of span roof called a "hip roof," and in fig. 31 the projection of that other class of a span roof called a "pavilion," sometimes a "coach-house" roof. Those projections, though mere diagrams to illustrate the application of the principles of projection, give, in fact, the method by which working drawings of such roofs of whatever kind, and with various details, would be prepared.

Should the sides of the blocks projected show any peculiarity of arrangement, such as an aperture or hole at a certain part of the surface—such parts may also be projected on the general projection.

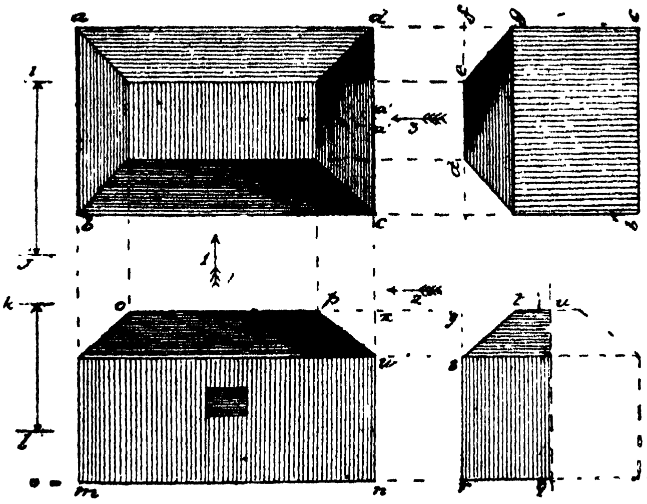


Fig. 31.

THE CALICO PRINTER.

THE CHEMISTRY AND TECHNICAL OPERATIONS OF HIS TRADE.

CHAPTER XIII.

AT the conclusion of preceding chapter we gave some calculations respecting hydrometer glasses; we now in connection continue these. Thus, to convert specific gravity into degrees Twaddle, subtract 1 or 1000 and divide by 5. Thus, 1030 sp. gr. *minus* 1=30, which divided by 5=6°Tw., or 1030 sp. gr. *minus* 1000=30, which divided by 5=6°Tw. There are other hydrometers in use besides Twaddle's—such as Baume's, which is used on the Continent. For liquors lighter than water a hydrometer graduated in direct specific gravity is used; generally they are graduated from 1000 sp. gr. to 700. This hydrometer will show strong ammonia water to mark 800, and alcohol 810.

Oxalic Acid (C_2HO_4) is used in the discharge indigo bath, in bronze and Turkey-red discharges, and in resist and other colours. It is a strongly acid, corrosive, crystalline substance, soluble in 8 parts of water at 60° F., more readily so in hot water. Its use in "resisting" mordants, such as alumina, etc., depends upon the property it possesses of uniting with alumina to form a compound which does not take up colouring-matters like most other alumina salts. In strong solution it exercises a destructive action upon cotton, and hence too strong solutions cannot safely be printed on. White cotton is injured when printed with starch paste containing about 1 lb. per gallon of oxalic acid and steamed.

Citric Acid ($C_{12}H_5O_{11}+3H_2O$) is used chiefly as a resist and in Turkey-red discharge. It is also found mixed with some tannic acid colours. It is a strongly acid, crystalline substance, soluble in its own weight of water at 60° F., and half its weight at 212° F. Citric acid is frequently used in the less pure but cheaper form of lemon or lime juice, which contains the acid along with various inert matter derived from the fruit from which it is extracted. Good lemon juice at 48° Tw. contains from 27 to 32 per cent. of pure acid (as $C_6H_4O_7$).

Tartaric Acid ($C_4H_2O_5+2H_2O$) is used for the same purposes as citric, to which it bears close resemblance in its properties. It is a strongly acid, crystallisable substance, soluble in water.

For *Arsenious and Arsenic Acids* the reader is referred to the division treating of the "Compounds of Arsenic."

For *Tannic Acid* the reader is referred to the division treating of the "Chemistry of Colouring Matters."

ALKALIES.

Soda Ash is used in bleaching. It is very variable in composition; the chief constituent is carbonate of soda (Na_2CO_3); but commercial soda ash also contains caustic soda (NaOH), and small quantities of inert salts, such as sulphates and chlorides of soda. If it contains no caustic alkali, it is necessary, for the purposes of bleaching, to render it caustic by the addition of a small quantity of lime, which forms with it carbonate of lime and caustic soda. It should contain only a trace of iron, for although iron, if present, would exist in an insoluble state, yet its presence is dangerous. The amount of alkali in soda ash varies from 45 to 57 per cent. of Na_2O, and it is usual to purchase it according to this percentage. Mineral acids and the stronger organic acids, such as oxalic, citric, tartaric, acetic, produce effervescence in soda ash, owing to the union of the acid with the soda contained in the alkali and the liberation of carbonic acid. Added in small quantities to salts of iron, alumina, chromium, magnesium, manganese, zinc, or tin, a precipitate is thrown down, which consists either of the carbonate or hydrate of the metal. It is strongly alkaline, but less so than caustic soda.

Soda Crystals ($Na_2CO_3 + 10\ H_2O$) is employed for making some mordants, and for purposes of an alkali. It acts the same as soda ash, but owing to its crystalline nature it is much less liable to contain impurities; it is, of course, not so strong as soda ash, since, according to its formula, given above, in every 286 parts by weight there are 180 parts by weight of water of crystallisation, and 106 parts by weight of carbonate of soda (Na_2CO_3).

Pearl Ash (K_2CO_3), corresponds to soda ash, and is similar to it in most of its properties. It can be substituted for soda ash, but it is dearer. It is used, after conversion into the caustic state by treatment with lime, for making soft soap.

Caustic Soda (NaOH) is used for neutralising lemon juice and similar purposes, and in making soap and oleine or alizarine—oil prepare. It is a strongly alkaline, corrosive, white substance; in commerce it occurs both in the solid and dissolved state; the former in lumps, or preferably in powder, containing 94 to 98 per cent. pure soda. Caustic soda neutralises all acids forming "salts"; it precipitates most metals like Na_2Co_3, producing the hydrates or the oxides of the metals. The solid alkali or the concentrated solution exposed to moist air absorbs water, and also carbonic acid, in the latter case being converted into Na_2Co_3. Hence its causticity decreases on exposure to the atmosphere.

A concentrated solution of caustic soda tenders the fibres of cotton; but a weak solution, properly applied, has the peculiar action of shrinking the cotton and giving its fibres a slight affinity for colouring-matter; or, in other words, slightly mordants them. This property has not yet found practical application.

Caustic Potash (KOH) behaves in most respects like caustic soda. It is employed mainly in making soft soap, and in making cocoa-nut oil soap for finishing. It is sold in solution at 70° Tw., containing 35 per cent. pure alkali (KOH).

Ammonia, or Volatile Alkali (NH_4HO, or $NH_3 + H_2O$). The chief uses of this alkali in calico printing are in "gasing" aniline black—*i.e.*, running the goods printed with aniline black, after ageing, through a box or room containing ammonia vapour, for the purpose of neutralising acid remaining in the colour. It is also employed in oleine making, and in one or two colours. Liquid ammonia is a solution of ammonia gas (NH_3) in water, with which it forms a hydrate, and hence is sometimes called ammonium hydrate, or hydroxide. On boiling the liquor the NH_3 volatilises. One ounce of water at 68° Fah. is capable of absorbing, under the ordinary atmospheric pressure, 681 ounces by volume of ammonia gas, the volume of the water increasing from 1 to 1·66 ounce, and the specific gravity decreasing from 1 to ·785. Commercial ammonia liquor has a specific gravity of about ·860, contains 27¼ per cent. of ammonia gas, and begins to boil at 62° Fah. The specific gravity of the liquor is a sufficient guarantee of its strength, as the lighter it is the stronger it is; hence, if it contain impurities, it will be heavier, and so appear of less strength than really may be the case.

SALTS OF THE ALKALIES, ETC.

Common Salt or Chloride of Soda ($NaCl$), is used in chroming pieces for lead yellows and oranges—*i.e.*, passing them through chrome and salt. It is used very extensively in soap and oleine making. Added to soluble lead salts, such as sugar of lead, or to soluble salts of silver, or protoxide of tin, white precipitates of the chlorides of the respective metals are thrown down.

Sulphate of Soda (Na_2SO_4) is used in admixture with bichrome for raising lead yellow and orange Added to lead salts, it throws down the insoluble sulphate of lead.

Chlorate of Soda ($NaClO_3$) is used as an oxidiser, chiefly for aniline and logwood black and catechu brown. It is a crystallisable deliquescent salt, readily soluble in water, and owing to its greater solubility than the corresponding potassium salt ($KClO_2$), is used in preference.

Arseniate and Bin-arseniate of Soda, or Dunging Salts (Na_3AsO_4 and $NaHAsO_4$).—These salts are now extensively used as substitutes for cow-dung in the treatment of alizarine and other mordants printed on. They are compounds of arsenic acid with soda. The latter contains more arsenic acid than the former; the bin-arseniate is of slightly acid reaction, and hence some dyers neutralise it in the vat with soda ash, converting it into the arseniate. The chief action of these salts on the aluminous mordants is to unite with the alumina to form the very insoluble compound arseniate of alumina. It is probable also that they have a positively cleansing action on the cloth, removing the thickening with which the mordant is printed on. Their nett value depends upon the amount of arsenic acid and impurities they contain, the only way to ascertain which is by chemical analysis.

Silicate of Soda, or Water Glass, or Soluble Soda Glass ($NaO \cdot SiO_3$).—This salt, as bought in solution at 24° Tw., is also used in dunging, silicate of alumina being, like the arseniate, an insoluble compound. It is generally used in conjunction with the arseniate. It was formerly employed to fasten ultramarine blue and other pigments.

Borax, or Pyroborate of Soda ($Na_2B_4O_7 + 10H_2O$).—This salt is used for fixing one or two aniline colours; also for dissolving white arsenic in place of glycerine for mixing with aniline colours. It is crystalline; soluble in 12 parts of cold water, 2 parts of boiling.

Citrate of Soda ($Na_2C_{12}H_3O_4$) is used for the same purposes as citric acid, and is preferable in most cases, being less liable to injure the cloth.

Acetate of Soda ($NaO_2 \cdot C_2H_3$) is a useful salt, and frequently used in colour mixing, for the purpose of neutralising any traces of mineral acid that may be present in the colour. It is a highly soluble, readily crystallisable salt, uniting with three molecules of water.

Bisulphate of Potash ($KHSO_4$) is used as a substitute for tartaric acid for cheap work, but is much inferior to the latter salt, and is apt to injure the cloth.

Chlorate of Potash ($KClO_3$) is used for the same purposes as the soda salt, but has the disadvantage of being less soluble and dearer. It is, however, extensively used for aniline black and catechu brown. It is a crystalline salt soluble in 17 parts of water at 59° F. and in 5 parts at 212° F.

Chromate of Potash or Yellow Chrome, (K_2CrO_4).—This salt is employed in indigo discharge colours, and in preparing chromate of lead pigments. It is a bright yellow crystalline salt, of alkaline reaction; soluble in 2 parts of water at 60° F. The addition of an acid changes its colour to orange-red and converts it into bichromate. It is frequently adulterated with sulphates.

Bichromate of Potash, or Bichrome ($K_2Cr_2O_7$) is one of the most important salts to the calico printer and dyer. Its uses are very numerous, the chief being that of "raising" colours. It crystallises in beautiful deep orange-red crystals, which are soluble in 10 parts of water at 60° F., and is of acid reaction. Addition of caustic potash converts it into the yellow chrome. The commercial article is generally pure.

THE SANITARY ARCHITECT.

THE PRINCIPLES AND PRACTICE OF HIS WORK, IN HEALTHY HOUSE ARRANGEMENT AND CONSTRUCTION.—TECHNICAL POINTS OF SEWERAGE AND DRAINAGE, VENTILATION, ETC.

CHAPTER IV.

LET, then, good boarded floors be given to the kitchen and working apartments, so that cold surfaces, upon which servants have to stand so long—as in the washhouse and scullery, or go over so frequently—as in the case of the kitchen, be avoided.

In the case of the superior apartments of the house, the utmost care should be taken to secure a dry under surface below the floors. By far the most effective way in which to secure dry floors to these rooms is to have them cellared under. These cellars so formed will be also exceedingly useful for many household purposes, such as the storing away of provisions, keeping of beer, wine, etc. The expense of these under-floor apartments is, however, often objected to,—although with what reason we fail to see, as we consider a cellar to be as essential as any other room, on the score of the convenience it affords, to say nothing of the part it plays in keeping the house dry. But if the expense be really objected to, a greater amount of care should be observed to see that the underneath space below the ground-floor rooms is in a healthy condition. Few have any conception as to the state in which the soil is often left below a drawing-room or a breakfast-room floor. No wonder that smells are complained of! If the boards were taken up in such cases of smells, their cause, and something else, could easily be accounted for. The way in which the spaces under the floors are often left by the workmen is highly culpable. Wood shavings, oily rags, pieces of wood, and other things besides, are left to rot and fester below, and send up through the chinks of the floor all manner of smells marvellously foul. And more than this—and worse than this—drains are sometimes led right across the site and through and under the floor soil; and these, getting out of repair, add a thousandfold to the evil condition of matters.

The soils below all ground floors should be taken out for some depth—the deeper the better—and the excavation filled up with dry materials, as non-absorbent as possibly can be got, such as cinders, smelters' clinkers—the more vitrified the better—pieces of broken gas retorts (earthenware ones we mean, of course), or the slag from iron-works. And even when this is done—and, of course, much more when it is not done—in no case should the flooring joists be placed in contact with the soil, or with those materials, but a space in all cases should be left. Where the best, the most perfect, method of finishing the surface of the soil below ground floors is desired, the whole surface should be covered with a layer of Portland cement concrete. This, which is now being largely introduced for paving and flooring surfaces, is almost wholly impervious to damp, is non-absorbent, and so hard as to be completely vermin-proof. If, in addition to the soil beneath the floors being laid with this concrete, it passed under the foundations—or rather, if they were built upon a layer of it, extended for some few inches beyond the wall—we could scarcely conceive of a house being damp. As bearing very closely upon the subject of the soil of the site of a house in relation to the health of its inhabitants, it will be worthy of the attention of our readers to note the researches made by eminent savants as to what may be called the "aerial" condition of our soils: thus, a gravelly soil has been found to contain one-third of its bulk of air—and the air of soils to be highly charged with carbonic acid gas. Taking the proportion of volumes of this gas at six to each ten thousand volumes of what may be called the atmosphere of a house, as yielding what may be taken as the standard of healthy air to breathe in it, some idea may be formed of the highly unhealthy condition of the air of soils, when we state that Boussingault showed that in some soils the proportion had risen to so high a figure as nine hundred and seventy-four volumes of carbonic acid gas to ten thousand of air, some two hundred and twenty-one, some one hundred and seventy-nine, and some ninety-six.

Now, when we consider the comparative ease with which gas is drawn, so to say, from and through a soil—and this draught is exercised so strongly that the gases are drawn from comparatively great distances—and, further, when we consider that this drawing power is greatly aided by the action of fires in apartments, we can easily see the importance of attending to the state of the soil below and surrounding our houses, so that none of the "evil conditions" too attendant upon soils, some of which we have named, shall exist, and that all means be taken to prevent their acting—if they do exist—injuriously on the health of those who live in the houses built upon them.

Having thus thrown out a few hints in connection with the important department of the site of houses, we now proceed to the consideration of other departments; and the first we shall concern ourselves with will be the building of the walls, or rather certain points connected with these: for the practical details of building our readers are referred to the paper called "The Stone Mason." We have already, in this and a preceding chapter, drawn attention to the influence which damp exercises on the health of those living in a house affected, so to say, by it. Now, a very commonly met with source of damp is the walls; and this arises first from the way in which their foundations are made, and secondly from the way in which the superstructure or upper parts of the walls is or are built. First as to the foundations. Much of the damp which is found in walls would be prevented if the site were thoroughly drained, as recommended in an earlier chapter; and this as a preventive is perhaps one of the most to be relied upon, and if effectually carried out, no other need be tried. Still, in order to make sure work, it will be well to lay the foundation above a bed of concrete; which may be either of the ordinary kind known as lime concrete, or of that called cement concrete, to which reference was a short space above made. This precautionary measure is all the more essential to be carried out in clayey and retentive soils, for however well they may be drained, a good deal of wet flows in from the surrounding soil, and attacks the foundation. Further, unless the roofs are well guttered, the drip from the eaves, falling as it does so close to the walls, runs down and comes in contact with the foundation.

The concrete, therefore, of whatever kind used, should not be merely of the breadth of the foundations, but should extend beyond them for some inches outside. And in addition to these measures it will be all the better if a "damp-proof course" is laid round the whole range of wall. This is generally made either by building in a course of slates, or a sheet or strip of lead, or by spreading a layer of tar, the height at which these materials are laid being some few inches below the ground level. Hollow or perforated bricks—in the case of brick walls—are also becoming extensively used as damp-proof courses. But in all the object is to prevent any damp which the foundation and lower courses may gather from the soil, reaching to the upper courses and through the whole wall in the course of time, which it is sure to do if it once fairly gets possession, so to say, of the foundations.

It is impossible to err in being too careful in the construction of the foundations of a house: not only should they be of the proper and full width, carefully bedded on good concrete if the character of the soil demands this, as already stated, but of solid work throughout: no broken bond in the bricks should be allowed, no mere facings of stone,—if this be employed, the interior being filled up with any sort of rubbish or grouted with poor mortar, such work will never be satisfactory.

As regards the walls themselves, we may here draw attention to a point which is much discussed—namely, the inferiority of bricks as compared with stones—the first by many being supposed to give a wall peculiarly liable to damp. Now, we believe that if a fair and a very wide survey were made of the houses throughout the country, there would be found, as a result, that the greatest number of damp houses are those built of stone. Taking like quantities or standards of each, brick is less absorbent than stone; and if not so, it possesses this advantage, that there are greater chances in favour of its drying much more thoroughly and quickly than stone. When once stone of such qualities as are generally used gets thoroughly saturated with damp, there are very few chances in its favour of becoming thoroughly dry again. No doubt there are some kinds of stone which do not so readily take up the damp; but even these, when once they become so, are long in becoming dry.

Much also depends upon the way in which stone walls are built; for not seldom they are, as hinted above in connection with foundations, mere sham built, professing to be thick walls, and with all the thickness made up of solid stone well bonded, with "throughs" at proper intervals, but merely professing to be such, for the facings only are what the wall professes to be throughout the interior. To make up the thickness, which is boasted of by the builder, and trusted to by the employer as giving thickness, and therefore warmth, strength, and immunity from damp, the interior is filled up with stone shivers, or a poor quality of rubble work, and grouted with mortar too often of a poor quality also. Now, this honeycomb wall is a mere deception, and if once the interior gets saturated with damp, farewell to the dryness of the outer, or what is worse, the inner face.

There are some qualities of stone so absorbent—being so porous and full of small cells, so to say, that they suck up water like a sponge, and the cells, as we call them, retain the water—that there is little chance of a wall built of it being a dry one for any length of time, the first wet winter doing mischief which several dry seasons will not undo, and this even in cases where the walls are honestly—that is, solidly—built. Stone of such qualities should never be used; and it will be worth the exercise of a little trouble to ascertain, previous to using any stone, what are its characteristics. There is a very useful table published in the majority of building works showing the absorbent qualities of a great variety of building stones, this being the result of a parliamentary inquiry. A good precaution in stone walls, and also in those of brick, is having them built as "cavity" walls—that is, with a hollow space in the centre of the wall. Damp from the outside rains will not penetrate, or at least will not reach so quickly the inner face, if the walls be built thus. Brick affords greater facilities for the formation of cavity or hollow walls than stone; and a wall which, as an ordinary 9-inch one, would be liable to damp, built as an 11-inch cavity wall has a very good chance of being dry.

THE CARPENTER AND HIS TECHNICAL WORK.

Its Origin and Early Work—The Principles and Details of its Practice.

CHAPTER XI.

At the end of last chapter, in describing the method of joining pieces of timber at right angles, we stated that the neatest joint of this class was that with the mortise and tenon joint at the mitre or angle. This is shown in detail in the other diagrams in fig. 53. In place of cutting the part, as shown by dotted lines at *a b*, right off across its thickness or edge, a thin part forming the tenon is left in the centre of the thickness, as at *i* in the piece *j j* shown both on side and edge view. On the angular or mitre face of the other piece, as *c d*, a groove in the centre is cut a little less in breadth than the thickness of the tenon *i*, shown in plan of top edge at *n* in piece *o o* corresponding to piece *c d*, which is side view. When the two pieces thus formed are put together they present the appearance as at *h i*, which is a view of top or plan.

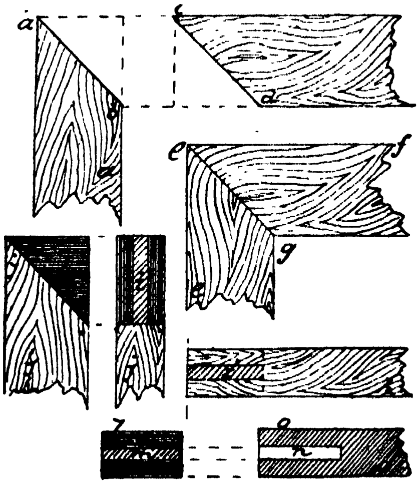


Fig. 53.

Various joints are illustrated in connection with partitions, joists, and roofs, which form the subject of succeeding paragraphs. Some of these joints employed in the construction of those classes of framed carpentry work have already been illustrated, and to these reference will again be made. We now proceed to illustrate others, the whole comprising almost every kind of joint used in framework. In examining at a future stage of study the illustrations we give of partitions, floors, and roofs, the young carpenter should have no difficulty in seeing at what points the joints now to be illustrated are employed. Reference will, however, be made to the most important points of these.

Special Joints used in the Framing of Partitions.

In fig. 54 we illustrate a method of joining used in partitions. *a a* is part of the sill, *b* the upright post or stud, the joint being a mortise and tenon; *d* is the foot of one angular brace or stud, let in at *e* into a recessed part cut out in the upper face of sill or cill *a a*. This recessed part may be cut out right across the face of sill, and the end of *d* left square. A better class of joint, however, is had by leaving a tenon, as *j*, at the foot of the piece *i i*, corresponding to *d*, which tenon goes into a mortise cut in the face of part cut out of sill *a a*. This mortise is shown at *p* in piece *o*, which is the upper face of sill; *m k l* and *m n* are other views of this joint. The end of brace or strut *d* is sometimes cut angularly, as at *g f* at foot of *h* corresponding to *d*. The filling-in pieces, as at *a b*, fig. 6, Plate XI., of a partition are jointed between the face of a strut or brace *a a*, by simply cutting the foot of *b* at the desired angle; the upper end being level or horizontal to correspond with the under side of the horizontal head of the partition, and filling-in pieces, as *b*, being simply jammed and driven tight into the places. But the better forms of joints for foot of filling-in pieces are shown at *c d*, *e f g*, and at *h*, that at *c* being simply an angular piece cut out right across the face of the stud or brace, as *a a*, the foot of piece, as *b*,

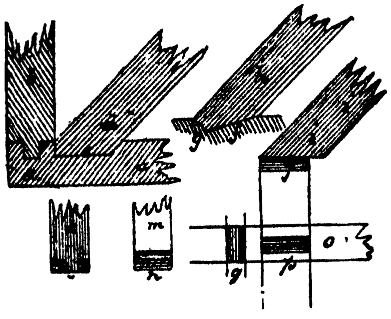


Fig. 54.

being cut to correspond. This joint gives security against the foot of piece *b* sliding down the face of strut *a a*, which the simplest form of joint at *b* does not give; but it gives no security against lateral pressure tending to force the foot of *b* out of contact with face of *a a*. Security against pressure in all directions is given either by the form of joint shown at *f*, this being a tenon cut in end of piece *g* and let into a mortise cut in face of brace *e*; or the tenon may be formed as at *h*.

Special Joints used in the Framing of Floors, Joists, and Wall Plates.

We come now to the joints met with in the framing of floors and roofs of different classes illustrated in a future chapter. Already we have given, in fig. 43, an illustration of the form of joint used in joining the end of a floor joist, *a a*, with the wall-plate *b*. The groove *c d* on face of wall-plate *b b*, with cross-rib or feather, receives the end of the joist, the feather *e* passing into a groove cut in the end of the joist. The lower part of the diagram in fig. 43 illustrates a modification of the dovetail joint for the joining of joists with wall-plates fully described in connection with this figure. Fig. 39 illustrates a method of joining pole-plates *a* with the tie-beam *b* of a roof, forming truss *c d*; in same figure another method, a groove being cut in the edge of the tie-beam, as at *d*, into which the pole-plate is placed, is shown. In the first method a key, as *e f*, is passed into a groove cut as at *g* in face of tie-beam; a corresponding groove is cut of half the depth of key *f e* in face of pole-plate.

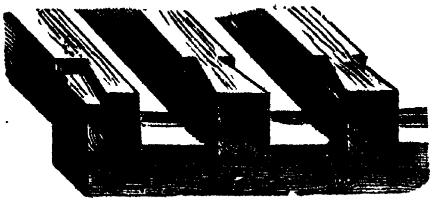


Fig. 55.

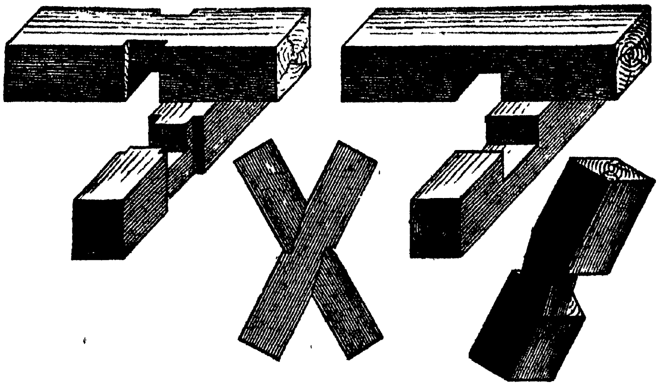


Fig. 57.

Fig. 38 illustrates the junction of the end of tie-beam with wall-plate; fig. 39 giving different views of the parts in fig. 38: *a* is the wall-plate to receive the key *c*, *f* side, *g* end view of the key. In fig. 42 the tie-beam *b* is simply notched into wall-plate *a a*. In fig. 36 a method of notching on the flooring joists, as *a a*, to the sleepers as *a*, is illustrated. Those sleepers rest on brick piers, and are generally employed when the width of floor is great, so that a support is given to the joists between the walls. In figs. 55, 56, 57, 58, we give perspective views of several of the joints already described in detail.

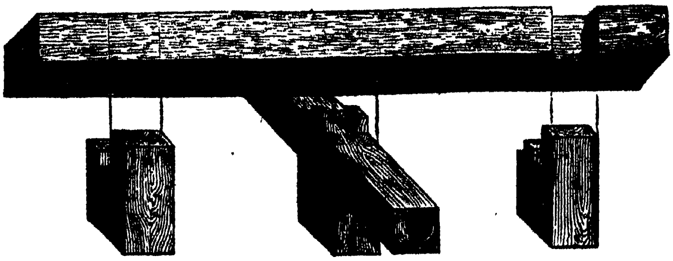


Fig. 58.

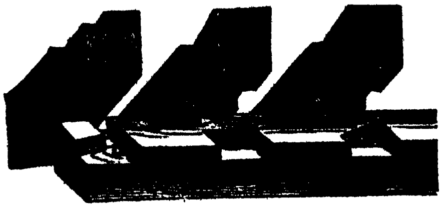


Fig. 56.

Joints used in Roofing.—Common Rafters with Pole-plate.—Queen-Post Roof Details.

In fig. 7, Plate XIX., we illustrate the junction of common rafter, *a a*, with a pole-plate *b*, this being secured to the tie-beam *c c* with a key *d*; *c* shows the end of the rafter *a a*, with piece cut out to notch or butt on pole-plate *f g* in cross section. Fig. 59 illustrates the junction of the rafter, *a*, of a "lean-to" roof (see a future chapter) with the wall-plate *b*, the gutter *c* being secured to ends of the rafters, which are lengthened or extended so as to pass beyond the front wall.

Fig. 60 illustrates the junction at part of a "queen post" roof truss (see a future chapter on Roofs). *a a* is part of the "principal rafter," *b* the purlin supporting or carrying the "common rafter" *c c*.

THE BRICKLAYER OR BRICKSETTER.

THE PRINCIPLES AND PRACTICAL DETAILS OF HIS WORK.

CHAPTER VII.

WE concluded last chapter (vol. ii. p. 265) by saying that in a well-built brick wall, stability was secured not only by means of the mortar, but by the bricks themselves being so placed that they will add to this. The whole, in short, must be "bound" together, so that the strongest possible wall may be obtained by the way in which they are related to each other. This is technically known as "bond," which has been already described in "The Stone Mason." But the pieces in brickwork are smaller than in a wall of the same dimensions built of stone, in which the pieces or blocks are large; they must therefore be much more numerous, and a more intricate kind of bond is demanded. There are, in fact, in brickwork more than one kind of bond. What these are we now proceed to illustrate and explain.

Bricks placed Longitudinally in Walls termed "Stretchers"—Transversely "Headers."—The Relative Positions of "Headers" and "Stretchers" in a Wall give the Two Kinds of Bond, known as "Old English" and "Flemish Horizontal Bond."

A brick having its length greater than its breadth is obviously capable of being placed "on bed" (see last par.) in two ways, with relation to the front or face of the wall, *a a*, fig. 8, Plate XIII. Thus it may be placed as at *b c d e*, or as at *f g h i*, the dotted line *a a* being supposed to be the front or face, or direction in which the length of the wall runs. When placed as at *a b c d e* the brick assumes a position which is technically termed a "stretcher"; when placed as at *f g h i*, a "header." By placing a number of bricks so disposed together, a wall of a certain kind may be constructed, of which we may suppose the plan to be at *a a*, *b b*, in fig. 2, *a a* being all "stretchers" and *b b* all "headers." But as a brick has a breadth just half the distance of its length, if placed as at *e f*, in relation to another, as *d g*, a space, as *h*, is left vacant, the reverse position being as at *i j* and *k*. In the central position, as at *l m*, *n o*, a space on each side of *l* and *n* is left vacant, as at *k*, *n* and *o*, this being equal to one-half of the breadth of a brick, as shown by the dotted line *p q*. Now, by arranging the bricks as in fig. 2, at *a a*, *b b*, a series of spaces, as *c c c*, are left at the back part of the wall, the lower line being supposed to be the front of this. These spaces in width are just half the length, and therefore just the full breadth, of a brick; and by placing bricks, and so filling them up, as at *c c c c*, a solid flat surface is obtained, all those, as *c c c c*, being "stretchers." Here we have a species of binding together of the bricks by the way in which they lie "on bed" in relation to another, and in which they are viewed from the "elevation"; the "stretchers," *a a*, alternate with the "headers," *b b*, as at *d d*, the latter being "stretchers" in elevation, corresponding to the "stretchers" *a a* in the plan; *e e* being "headers" in elevation, corresponding to the "headers" *b b* in plan. This arrangement is, in fact, that kind of "bond" known as "Flemish" bond, in which the "headers" and "stretchers" alternate; and the wall in fig. 2 would be what is technically called a "one-brick wall"—that is, a wall having a thickness equal to the length of one brick—or a brick, as *b*, placed as a "header," as at *f g*, *h i*, in fig. 8, Plate XIII., and *b b* in fig. 2. In place of arranging the bricks as in fig. 2, they may be placed in one row, as in fig. 3, these being all "headers," as *a a*; or they may be placed in two rows of "stretchers," as *b b* in same figure. If the row *a a* be placed above the row *b b*, so as to be as in "elevation" at lower courses *a′ a a′* and *b′ b′ b′*, fig. 3, the arrangement is that species of bond known as "Old English" or "English bond," in which there is one row entirely made up of "headers," *a′ a′ a′*, corresponding to *a a* in plan, and another row as entirely made up of "stretchers," as *b′ b′ b′*, corresponding to *b b* in plan. We shall see presently, however, that although fig. 2 illustrates the chief feature of what is called "Flemish," and fig. 3 that of "Old English" bond, the arrangement of the bricks as there given is deficient in giving a "*true* bond."

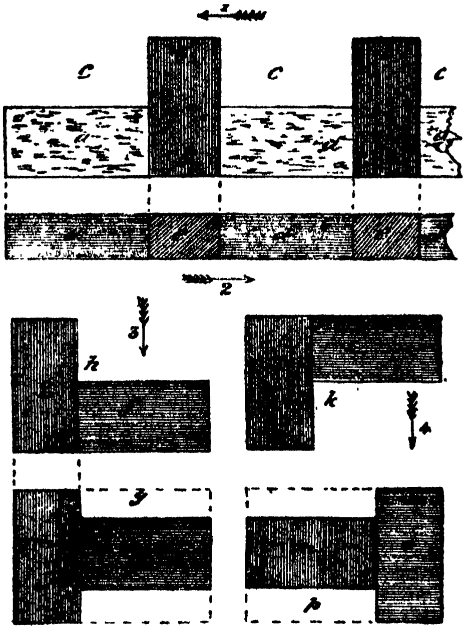


Fig. 2.

Any one row of bricks, as *a a* or *b b*, fig. 3, is known technically as a "course," and is equal in thickness, invariably, to the depth or thickness of a brick—the exception being when the bricks are laid or "set on edge" (see a preceding paragraph), which, however, is only done in certain kinds of work, as in forming the coping or last course of an open or exposed wall, and in a certain class or kind of hollow brickwork, hereafter to be described; in which case the depth of a course is equal to the breadth of a brick.

Walls built up in a Succession of Layers called "Courses," necessitating "Vertical Bond" as well as Horizontal.

In the arrangements thus so far illustrated in figs. 2 and 3, the "bond" or connection between the various bricks making up a course as lying "horizontally" is obvious enough while lying "on bed," or in "horizontal bond" as it may be termed; the bricks, as *a a*, *d d*, fig. 2, being clearly prevented from moving laterally or sideways, as in the direction of the arrows 1 and 2, by the bricks *b b* or *c c*, although there is nothing in the arrangement shown to prevent the bricks *b b*, *c c*, from being moved out of place by pressure acting in the direction of the arrows 3 and 4, save the cohesion of the bricks to those as at *a a* or *d d*, by means of the mortar or cement with which in practice they are laid.

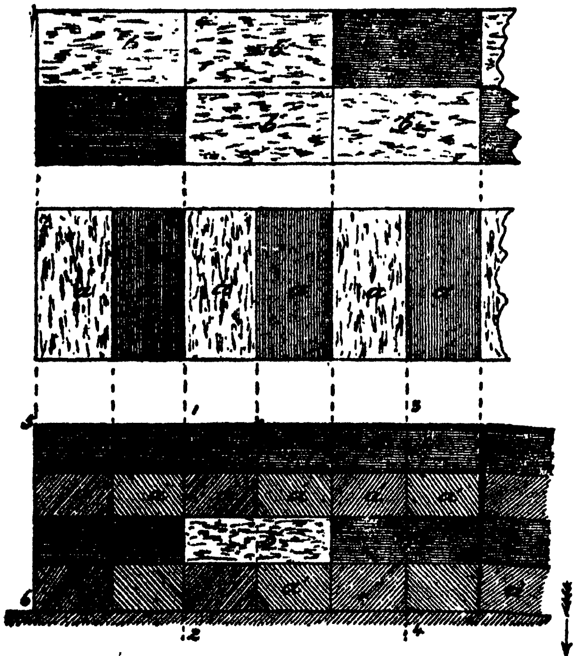


Fig. 3.

But as a wall, in the sense of its height, is made up of a succession of "courses," these also ought and require to be so placed in relation to each other that they will be connected or bound together—that is, there must be "vertical" as well as "horizontal bond." Thus, by placing the courses as shown in fig. 3, it is obvious that this "bond" is not secured, inasmuch as all the joints, 1, 2, 3, 4, run vertically in a line from top to bottom of the wall, and this would be the case however high it was. This, if carried out in practice, would form exceedingly defective walls; for any unequal settlement of the walls might, and would, cause a disrupture vertically at the joint or joints corresponding to or near the points of unequal settlement. One part would be thus torn away from another more or less completely, the joint being wider at the top than at the bottom, as shown in fig. 3, at *d d*; *a′ a′*, *b′ b′* being supposed to be a succession of "courses" of "stretchers," *b′ b′*, and "headers," *a′ a′*.

Relation of Bricks one to another in Vertical Bond.—"Breaking Joint."

Now, this evil is prevented from occurring, or its chances of occurring are at least greatly lessened, by so placing the courses in relation to each other that the joints shall not run in the same vertical lines as in fig. 3, at lines 1 2, 3 4, but shall "break joint," as the technical expression has it.

This "breaking of joints" is illustrated in fig. 4, and simply means that the joint formed by any two bricks placed together at any part of a "course" shall be covered by the solid part of the brick of the course immediately above and below it. Thus, in fig. 4 the joint *a*, formed by the juxtaposition of the two "stretcher" bricks, *b b*, is covered by the solid part of the "header" bricks, *c* or *d*, in the courses above and below it, while the joints *e e*, *g g*, are covered by the solid parts of the bricks *f f* and *b b*, the joint *h* of bricks *f f* being placed above the central or solid parts of *d*. Another arrangement of "breaking joint" is shown at *h h*, *i i*, in the same figure. We have used the term "covered" to denote how the upper and lower edges of the joints *a* and *i* of the two adjacent bricks *b b* and *f f* are concealed by the solid parts of the bricks above and below them. But the technical term employed is "butting" or "bearing." Thus the joint *a* is said to "butt" or "bear" against the solid part of the bricks above and below it, as the bricks *b b* and *d*. The lower edge of joint *i* "butts" against or bears upon the solid parts of the brick *d*. The young pupil will note that the bricks *b b*, *e e*, and *f f* are "stretchers," while *c d* and *g g* are "headers." The diagram is not designed to shew any particular kind of "bond," but simply to illustrate what is an essential feature of every kind or class of bond—namely, the "breaking of the joints"; the joints in all cases being so arranged that they all butt against or bear upon solid parts of other bricks lying below or placed above them.

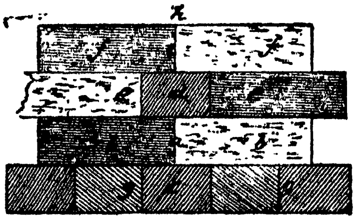


Fig. 4.

THE STONE MASON AS A TECHNICAL WORKER.

THE PRINCIPLES AND PRACTICE OF, AND THE MATERIALS HE EMPLOYS IN, HIS WORK.

CHAPTER X.

In preceding chapter we gave a sentence or two partly descriptive of methods of strengthening buildings by means of iron rods. Referring the reader to this (p. 21) we proceed with the description of the illustration now given. The bolts (*c*, *c*) are passed right through the apartment from side to side, being most conveniently placed below the flooring, *d d*, and then passed through holes made in the walls, *e e*, and secured by bearing plates and nuts, as at *f*, in the same way as shown in fig. 60. If used as a preventive of the walls bulging out, the nuts are at first screwed loosely up till settlement of the walls has taken place, when they are tightened. If the method is adopted after the walls have begun to bulge out, they can be brought back to the straight, after fixing the bolts and screwing the nuts up as tightly as may be; then by heating the body of the bolt it is expanded, and the consequent lengthening presses the nuts outwards away from the bearing plates, which can now be screwed tightly up against them again. By doing this with care and judgment the walls bulging out, as at *b b*, can be brought vertically up, as at *a a*. A front view of a form of bearing plate is shown at *g g* in fig. 61. It is usually made of cast iron, and as it is seen on the outside of wall it is made more or less ornamental.

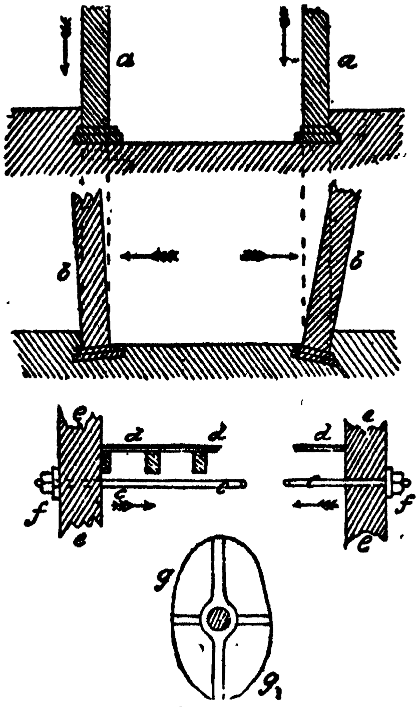


Fig. 61.

Binding together Blocks or Courses of Stone by Flat Iron Tension Bars and Screw Bolts and Nuts.

We now notice the last of the methods of supplementary bond to stone structures. In this flat bars—called technically " ties " or tension bars (see the chapter on framing and framework under the head of " The Carpenter ")—are used in conjunction with screwed bolts and nuts. These tension bars or ties are laid flat between and bearing upon the beds of the courses of blocks in number and disposition as desired or deemed necessary to secure a certain efficiency in the bond which they give. These bars are shown at *a a* in plan in fig. 62, and in elevation at *a a′*. They are punched or drilled at intervals, to afford holes for the bolts, as *b b*, passing through; and these are secured by nuts in the way already described in connection with fig. 60 (*ante*). These nuts are shown at *c c* in plan.

The Shape or Configuration of Stones as forming Part of the Architectural Style or Design of a Structure.

We have in the early paragraphs of this paper traced the steps, supposed or conjectural, which were taken by the early workers, starting with the rudest collections of stones, in leading up to the systematic and more or less complicated method of arranging stones in walls under what is termed "bond." In doing so we have had of necessity much to do with the form, shape, or configuration of the stones employed in building walls of various kinds. When arranged on a plan beyond the simple forms of small buildings, and when they assume the form of structures to which the term architectural is applied, we find that the form or the configuration of stones takes a much higher development than is essential where wall construction considered purely as such is the work of the mason. If the term architecture be properly defined, as some define it, to be ornamented building construction, many of the parts of architectural structure being purely ornamental, the stones which are used to give those forms must be cut and dressed into forms or shapes in accordance with what is called the *style* of the

Fig. 62.

architecture. The peculiar features of the accepted styles will, if space permit, be discussed in a separate paper, to which the reader interested in the matter is here referred; and in the illustrations which will accompany this paper the peculiar forms to be given to stones will be traced. There are, however, certain forms of stones more or less but all in some respects ornamental, which are common to all structures having any pretence to architectural design, even when of the simplest character and plan. To these what may be called general ornamental forms we now direct the reader's attention.

Fig. 63.

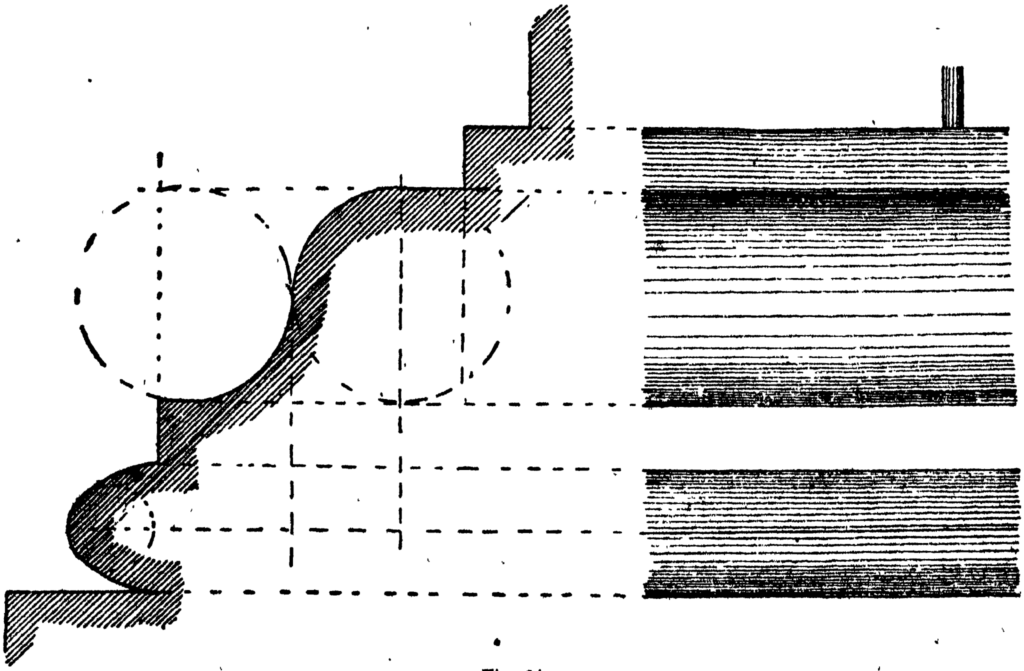


Fig. 64.

Lower or "Base Courses" of Walls of Public and Domesti Buildings.

Walls of houses rarely spring from the foundation courses so as to show a direct intersection with the ground surface, as at the wall *a* (fig. 63), springing at once from the ground level *b c*. This is only done in simple or plain buildings, such as stables, out-buildings, workshops and the like. In all domestic structures, save in the poorest or most economically constructed of cottages, there is a course termed a "base course" intervening between the ground level and the springing or start of the vertical wall. The simplest form of base course adopted is composed of a series of courses of brick or a course or two of stone of height equal to the rise of two or three steps by which entrance is gained to the entrance lobby. This is shown at *c* in fig. 63, *d* being the line of wall, at corner of side and end walls.

THE STEAM ENGINE USER.

THE DIFFERENT CLASSES OF ENGINES USED CHIEFLY FOR MANUFACTURING AND AGRICULTURAL PURPOSES.—THE LEADING DETAILS OF STEAM ENGINES—CONSTRUCTIVE AND OPERATIVE.—THEIR PRACTICAL WORKING AND ECONOMICAL MANAGEMENT.

CHAPTER XIV.

THE following is the description of the Heslop Engine, referred to at end of last chapter. "A Receiving Cylender, A (fig. 27) is placed under the beam of the Engine, B, between the centre of the Beam and the end opposite to that which is moved by and connected with the working Cylender, C, used in the Common Fire Engine. The aforesaid Receiving Cylender is filled with Steam from the Boiler, sufficient to produce a vacuum in the working Cylender for the next stroke of the Engine, and which Steam so received in reserve is made to assist in raising the piston, E, which must be loaded with so much weight upon every square inch as the Steam shall be stronger than the pressure of the Atmosphere, and which will consequently assist the Engine in its effect by giving an opportunity of loading the working piston F with the same weight. Near to the middle of the said working piston F is placed a Valve, L, which admits of the discharge of a small portion of Water, which rises on the descending stroke of the said Piston F, and supplies the same with Water. The Steam Valve marked G, which opens the communication between the Boiler and the Receiving Cylender, is similar to that in the Common Engine, and worked in the same way. The passage for the Steam from the Receiving Cylender to the Cylender is by a connecting pipe, H, which d and shut alternately by Valves marked I and K, and the motion is communicated to those Valves by working gears nearly similar to that of the Common Engine. The Working Cylender C, together with the connecting pipe H, to be constantly immersed in cold water. The Injection and sinking pipes of the working Cylender are all similar to those in common use."

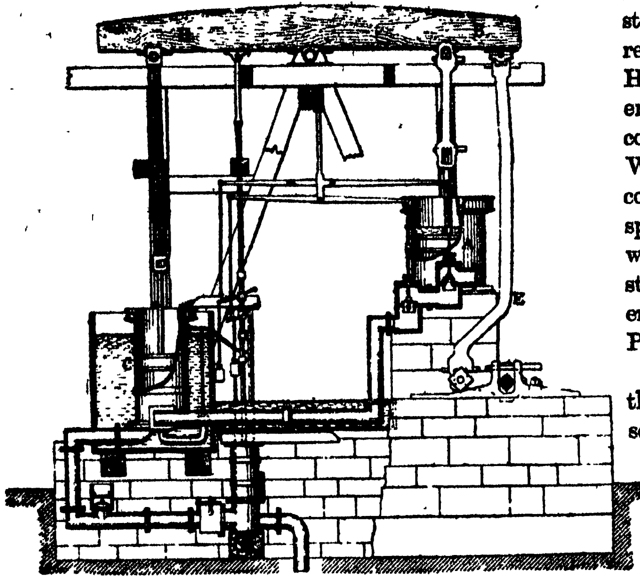


Fig. 26.

The foregoing is the description given by Heslop in his patent specification of 1790; and in connection with it the writer of the paper referred to says that, so far as he is aware, there is no work upon the steam engine which "contains any mention of the remarkable and ingenious engine invented by Adam Heslop, and patented on 17th July, 1790." This engine he considers "as a somewhat successful competitor with the improved engine of James Watt, and as containing within it the germ of the compound engine of the present day." The only specimen of this "family" of engines now remaining was lately set up in the Patent Office Museum, and stands close to the celebrated Soho Sun-and-planet engine of Watt, and the Rocket, Sanspareil, and Puffing Billy locomotives.

With the aid of the drawing, fig. 26, the working of this engine will be easily understood. "It will be seen that it is furnished with two open-topped cylinders, one on each side of the main centre of the beam, and both of them single-acting, although their pistons are acting in the same direction. These cylinders are described respectively as the 'receiving cylinder' and the 'working cylinder,' the latter being possibly so called lest Boulton and Watt should contend it was only a condenser with a piston

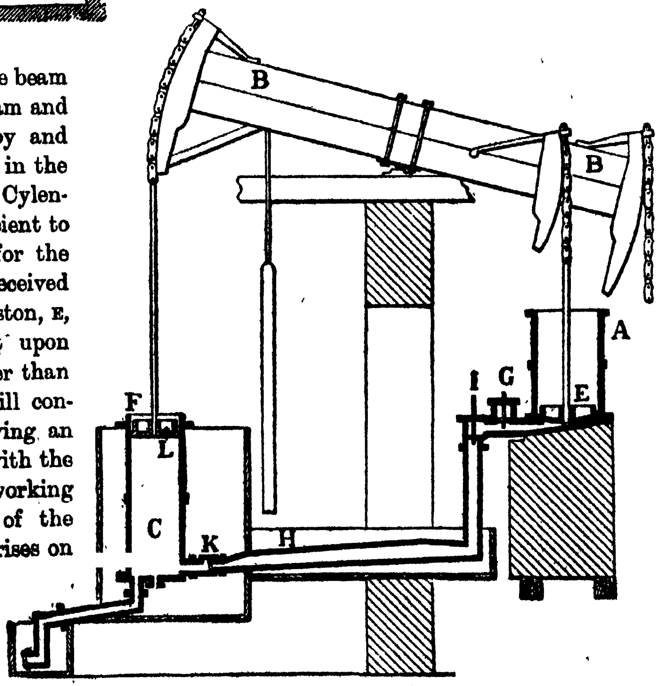


Fig 27.

in it; but in actual practice they were known, and perhaps more correctly, as the hot cylinder and the cold cylinder. The steam on being admitted into the first or hot cylinder helps to raise the piston by its pressure underneath; the return stroke is then made by the weight of the pump-rods, etc., in the pit, suspended by a chain working over an arched beam-head. During the downstroke of the pump-rods the eduction valve I being opened, the steam passes from this cylinder to the second or cold cylinder by means of the connecting pipe, constantly immersed in a trough of cold water, which produces sufficient condensation to 'kill' or reduce it to atmospheric pressure as it enters and fills the cold cylinder. The cold piston having arrived at the top of its stroke, and its cylinder being thus filled with steam, the injection valve is opened, admitting a jet of water beneath the piston, and thus bringing a vacuum into play. In the case of rotative engines the return stroke was made by the weight of the connecting rod, crank, and a heavy pair of links attaching the hot piston to the beam, assisted by the momentum of the fly-wheel. Weighting the pistons in order to profit by the pressure of steam is necessitated by the arched head and chain connection, which, though proper to receive a pull, will not admit of a thrust. In order to prevent the possibility of injection-water passing from the cold cylinder to the hot one, the latter is elevated above the level of the former."

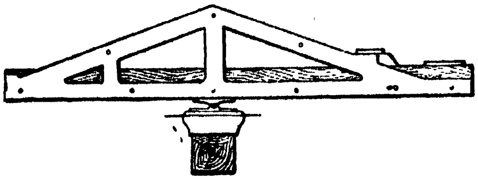


Fig. 28.

By so arranging the two cylinders, Heslop obtained advantages "approaching those of the separate condenser, and effected a signal superiority over the atmospheric engine of Newcomen." The engine here described is the one illustrated in fig. 27, the drawing of which is taken from the specification of July 17th, 1790; whilst fig. 26 is a drawing of the engine now in existence in the collection at South Kensington.

The beam illustrated by fig. 28 was one used on a large winding engine made by Heslop. It was a combination of wood and iron, consisting of two castings, bolted together, with a log of wood between them. The piston-rod of the cold cylinder of this engine was connected to the beam by means of a parallel motion similar to that illustrated hereafter in connection with Watt's specification. This engine was also provided with a crank and a fly-wheel twenty feet in diameter.

The engine at South Kensington Museum is thus described in the paper just referred to. "The hot cylinder, A (fig. 26), is 34 inches diameter, with 2 ft. 10 in. stroke; and the cold cylinder, C, 25½ in. diameter with 3 ft. 3 in. stroke. The wooden beam, B, has been frequently renewed, and a symptom of fracture in the present one is met by two pieces of old boiler-plate patched over the middle portion; the present hog-backed shape is modern, the original beam having been parallel in form. The air-pump of 12 inches diameter has been an after-addition; and the snifting valve in the cold piston is plugged up, being apparently no longer necessary. A drawing made about the year 1823 shows an air-pump placed outside the cold cylinder and worked through a double-radius parallel-motion, by means of a small beam attached to the end of the main beam by a long connecting link. Nevertheless the cold piston still did its work through a chain and arch-head, and it was probably not till 1837 that the now existing links and cross-head guides were substituted. The original cast-iron fly-wheel shaft has been replaced by a wrought-iron one of the same dimensions. The curiously bent connecting rod, E, was a common feature in all Heslop's rotative engines; and though its obvious intention is to clear the hot cylinder, he contended that it gave a certain amount of elasticity which was beneficial and desirable. The cold-water pump discharges itself upon the top of the cold piston, from which it overflows on the upstroke into the cistern in which the cylinder is placed."

The Crank.—In the earlier days of steam engines the crank was a thing unknown as applied to an engine. The principal use to which engines were put at that time being for pumping, made it a comparatively simple matter to attach the pump rods direct to the working beam; and as the steam forced the piston down in the cylinder one end of the beam was pulled down with it, and as the other end rose up the pump rods were also raised, bringing with them their charge of water. The weight of the rods was then sufficient to raise the piston to the top of the cylinder ready for the next stroke. To Watt is due the application of the crank as a means of converting the reciprocating motion of the piston into the rotary motion of the shaft. Watt himself says regarding his inventions: "Having made my reciprocating engines very regular in their movements, I considered how to produce rotative motions from them in the best manner; and, amidst various schemes which were subjected to trial or which passed through my mind, none appeared so likely to answer the purpose as the application of the crank in the manner of the common turning lathe." But as we read on, we find that though he first suggested such an arrangement, he was forestalled by a rival.

THE LAND DRAINER.

DRAINAGE OF LANDS OR SOILS SUITABLE FOR THE CROPS AND LIVE STOCK OF THE FARMER.—ITS HISTORY, PRINCIPLES, AND PRACTICE.

CHAPTER V.

First Advance toward the Use of the Covered or Underground Drain.—The Great Feature of the Modern System of Deep or Thorough Land Drainage.—Some Points in the History of its Introduction.

WE have seen illustrated in fig. 3 how the drainer in times long gone by made the first step towards the improvement of the open surface furrow, as at *e* and *f* in fig. 1, and as in fig. 2, in getting a more trustworthy and effective carrier away of such water as was shed into it from the surrounding near surfaces by deepening the furrow *h* till it assumed the form of a well defined channel, as at *g*. The truth of the fact in hydraulics that the velocity of a stream of flowing water is decreased in proportion as the area of the channel in which it flows is increased, is likely to have struck some observant drainer or farmer; and as his object obviously would be to get the water away from his field as fast as possible, he would naturally proceed to narrow the trench he had formed, as at *g*, and thus in process of time he would reach the section as at *j k*, narrower at bottom, where the water collected and along which it flowed, than at top, over the edges of which the water from the ridge surfaces on either side would flow. This section is that, in point of fact, adopted in the modern practice of stone-filled drains, as shown in the succeeding illustration, fig. 3. But while this form of drain would be a great improvement on the old form of open furrow, it possessed disadvantages. One would obviously be the open surface which it would present in practice. This would be got rid of by covering up the drain with soil, as shown in fig. 3 in the sketch to the right.

Here we have the first germ of the modern system of land drainage, the characteristic of which is that the drain is *inclosed* in the *general mass of the soil.* Although the enormous advantages which flow from this principle when fully carried out, and which will hereafter be fully described, were obtained by this the first step to the modern system, they were so only in a very moderate degree; still the principle had been got hold of. And although it lay long dormant, and received nothing like even an approach to its full development in practice till towards the end of the first quarter of the present century, we shall now see that this fuller development was, so early as some two hundred years ago, not only foreshadowed, but in some full detail described, by an early writer on agriculture. This writer was Blith, author of the "English Improver Improved, or the Survey of Husbandry Surveyed," which was in 1652. It militates nothing against Blith's claim to be at least the first exponent of the modern inclosed and deep-set drain, to say, as has been said, that its exposition was of no practical use, as the system really did not crop up into practice for nearly two hundred years after. This is said, but it is somewhat difficult to prove; and it is just possible that Blith's advice to farmers quoted below—and seeing its bearing on the subject of modern drainage, it is well worthy of having a place here—was followed by some, and exerted an influence on the progress of draining. The system of drainage known as "Essex" was long in use in that county and in other districts; and it is exceedingly probable that it was in vogue in Blith's time: that he knew of it is clear enough, for he actually describes its leading points, but only to denounce its practice and to recommend his own and greatly advanced system. This Essex system consisted in the cutting of shallow trenches, filling them up with brushwood, hedge cuttings, and other such-like materials, and finally covering them up with a thin layer of soil, of depth sufficient and but sufficient to be free from the influence of the ploughshare. "Goe to the bottom," says Blith, "goe to the *bottom* of the bogg, and make a trench in the sound ground, or else in some old ditch, so low as thou verily conceivest thyself assuredly under the level of the springs or spewing water, and then carry up thy trench into thy bogg straight through the middle of it, one foot under the spring." After denouncing in no half-hearted terms the style of draining generally done, which he calls "a great piece of folly," he counsels a trench to be cut about the "bogg" (as he spells it), making one mark or two "just over athwart it upwards and downwards." Then the trenches so cut are to be filled partly up with "good green faggots, willow, elder, elme, or thorne," on the top of which the original turf cut off in forming the trenches is to be laid "greensward downwards," and over all the soil is to be put up to level of surface. In place of faggot filling it is specially worthy of note that Blith recommends the drainer to "take great pebbles, stones, or flint-stones" to fill up the "bottome" of the trench to a depth of "about fifteen inches." Here, allowing only for a moderate thickness of turf and final soil covering, we have a depth of drain greater even than is now carried out by some in several districts of the kingdom.

The Elkington System of Land Drainage.

A hundred years or so after Blith here thus foreshadowed the modern draining system, in so far as its depth is a principal point, a Mr. Joseph Elkington advocated and worked out a system of deep draining which was to a large extent adopted, and was deemed of such national importance that Parliament voted him a sum of money, the amount of which authorities do not seem to be well agreed upon, as it is stated by some as only one thousand, by others as much as five thousand pounds. We have said that the Elkington system was essentially one of deep drains; it is not now followed, although it possesses some points practically valuable in the getting rid of under springs, while some of the details of the method, such as the cutting and making of deep conduits or culverts of size sufficient to carry off large volumes of water, are just as applicable to and likely to be valuable to us as in Elkington's own time. The working out of the system assuredly paved the way to, if it did not include all the points of, modern deep drainage. The principles upon which Elkington proceeded are so well stated in the words of one of the greatest modern authorities on agriculture, that we give them here. They were based upon three alleged facts. "First, that water from *springs* is the principal cause of wetness of land, and if it be not removed, nothing effectual in draining can be accomplished. Second, that the bearings of springs to one another must be ascertained before it can be determined where the lines of drains should be opened; and by the bearings of springs is meant that line which would pass through the seats of *true* springs in any given locality. Springs are characterised as true ones when they continue to flow and retain their places at all seasons; and temporary springs consist of bursts of water occasioned by heavy rains, appearing at the surface at a higher level than permanent springs, and they are also occasioned by true springs leaking water, which always appear at a lower level than the true springs themselves. Without due consideration the appearances assumed by temporary springs may easily be mistaken for those of true ones. It is evident that drains formed through mere bursts of water cannot effectually drain land, which can only be accomplished by their passing through the true springs. Third, that tapping the spring with the auger is a necessary expedient where the spring is too deep for a drain to reach it. From these statements," continues the authority noticed—Mr. Stephens, the well-known author of "The Book of the Farm," and of the treatise from which we quote, "A Manual of Practical Draining" (Blackwood and Sons, price five shillings)—"it appears that true springs are to be found neither at the top nor the base of a rising ground, but that temporary springs may be found at both; that the more extensive the acclivity the more numerous the springs, whether true or temporary; that true springs may be removed by branch drains; and that at the base of rising ground the leakage of true springs may originate bogs or swamps. Hence Elkington's method as adapted only to those peculiar cases." That there are many districts in which ground of this character exists, and in the draining of which this method of deep drainage in which auger tapping of springs, deep seated, otherwise, might be usefully adopted, does not admit of doubt in the minds of those who know practically the peculiar circumstances of a too wide acreage of land at present almost wholly unproductive.

Smith of Deanston's System of Thorough Drainage.

From Elkington's time up to about the year 1823 little appears to have been done in draining, other than carrying out in a very limited way the olden methods of surface and shallow faggot or stone-filled drains. But in the year named, Smith of Deanston, a place in Scotland, advocated a system of drainage which was afterwards modified in the direction of greater depth being given to the drains than that introduced and carried out by the inventor, if we may so here apply the term. Smith of Deanston—for by this appellation he was during the later years at least of his useful life always, and is still universally called—was a universal genius, but a practical one; what his mind designed, that he carried out with all his might. To his genius both mechanics and agriculture owe not a few most valuable inventions. The principle of Smith's system of drainage involved two points: first, a depth of the drain greater than was the general practice at his time; and second, frequency of the lines of drains over the field. This frequency in the drains in conjunction with their depth insured, as Smith of Deanston maintained, such a complete action in the whole mass of soil within their range, that he gave to his system the name of "thorough drainage." Placing as a rule his lines of drains in the old or established furrows of the fields, the system was also often, and is yet called "furrow draining"; and as furrows usually run parallel to one another over the whole surface of the field, it was also sometimes, although not so frequently now, called the "parallel drain" system.

The "Parkes" or Most Recent System of Deep Drainage of Land.

While Smith of Deanston looked much to the depth, still it was more perhaps to the number or frequency with which the lines of the drains were repeated over the field that he trusted for their efficiency. Be this as it may, the next step in the progress of the art of draining lay in the direction of decreasing the frequency of the lines and increasing the depth of the drains. This system, which is now known as "deep draining," and which may be called the most advanced, and that advocated by the ablest agricultural authorities, owed its introduction to the well-known agricultural engineer Mr. Josiah Parkes, who as ably advocated as he energetically carried it out in practice. Compared with the old system, and even with the decidedly scientific system of Smith of Deanston, that of Parkes well earned the title of "deep" draining.

THE STEEL MAKER.

THE DETAILS OF HIS WORK—THE PRINCIPLES OF ITS PROCESSES—THE QUALITIES AND CHARACTERISTICS OF ITS PRODUCTS.

CHAPTER V.

Steel making Direct from the Ore (*continued*).—Practical Points connected with the Process.

AT the conclusion of the last chapter we stated that the problem to be solved in the direct process of steel making was really that of making the process a paying one. This claim has been made for the American bloomery process; but if the commercial success or paying capabilities of this be well established—which some seem to doubt—it is to be remembered that it is carried out under exceptional circumstances and with the aid of exceptional materials. What is wanted with us is, under our circumstances and with our own materials to make steel direct from the ores, so that it will not merely pay, but pay well—indeed, handsomely. For that is the object really aimed at; a business or a trade makes no pretension to be patriotic, it simply desires to have its work well paid; if other, as social advantages, arise from or flow out of the trade, good and well, but those are not what the trade aims at.

We have seen that steel can be made by the direct process with very simple—we might perhaps say by the simplest—of all apparatus and appliances; but that the successful solution of the practical problem under our circumstances and with our materials will depend greatly upon the character of the apparatus used is pretty evident. While it is true of every process in every art that the practical success of its working depends upon the apparatus and appliances used, this is specially true of the process of steel making, in which the temperatures required are exceptionally and absolutely high. And the difficulties are not lessened when we consider that all the details of established practice would seem to indicate that in the processes of steel making we shall require temperatures much higher even than those we now use. At present the high temperatures which the steel maker can command are in a sense limited simply because the apparatus and appliances used to produce those temperatures are also limited in their action. But that we shall see, and perhaps shortly, methods introduced by which we shall have temperatures at present unattainable, we have no doubt. What has been done in the past in this direction is a guarantee, we think, for the future: we use daily temperatures which even by the most sanguine of scientific men twenty-five years ago would have been considered as beyond the possibilities of production by appliances contrived by man.

Some of the processes of making steel direct from the iron ores which have been introduced from time to time have been assuredly successful in the production of metal of a good quality,—in some cases, as notoriously in that of Mushet, of almost the highest quality. But none have been commercially successful. This has arisen from some inherent defect in the apparatus or means employed to reduce the ore affecting the precision with which results could be obtained, or from lack of a capability to increase the productive power of the apparatus, however well designed otherwise, so as to produce the steel in sufficiently large weights to make it "pay," and to meet the demand ever existing for steel of good quality. Frequently also good processes have proved failures simply from lack of the capital to make them successes. This capital is imperatively demanded, for it is required to carry out the initial experiments consequent upon and demanded by all new discoveries and inventions, and thereafter to erect the "plant" necessary to manufacture the product on a large scale, and also to meet the ever recurring demands which are made during the period when what is called making or establishing a business connection is going on. All those are considerations of the first value as affecting the interests and insuring the success of a new process.

Success in making Steel direct from the Ore largely dependent upon the Form and Character of the Vessels and Appliances employed.

But however abundant the capital, and however great may be the energy which the patentee has at command, it is obvious that any process of making steel must depend for its success upon the apparatus employed, however sound may be the principle upon which that process is founded. The history of patented inventions alone has furnished but too long and too painful a list of examples to permit of any doubt arising upon this point. Not a few discoveries have been made which beyond a doubt were of the highest value, possessing the "potentiality of making the discoverers rich beyond the dreams of avarice," which have failed utterly as commercial successes, solely through the impossibility of devising and constructing the apparatus required to make the discovery successful. These difficulties have at last triumphed, having either exhausted the ingenuity or the capital at command of the discoverer. A very remarkable example of the contrary is known to every one in the Bessemer process, of which it may be said that its immediate success, at least its comparatively quick reception by the trade, arose from this fact. That the apparatus designed by the inventor (then Mr., now Sir Henry Bessemer) was by the exercise of his rare mechanical ingenuity, aided by that daring dash (so well described in the French word *élan*) which so generally commands attention, was at a very early stage so perfect, so completely adjusted to the requirements of the process, that it is practically the same now as when first introduced—experience in this case, so unlike that of other inventions, having brought out practically nothing which necessitated a change in the apparatus employed. We shall have more to say on this and other cognate points when we describe the Bessemer process.

In the case of the processes of making steel direct from the ores, one great difficulty, if indeed it be not *the* one difficulty encountered, is the character of the vessel employed in reducing the ores. A very little consideration will show that in order to make steel of any given or required quality there must be the power so to work the apparatus that it will give definite results, which can be relied upon to be produced always. Any one of a series, be it long or short, of results will not do; it must clearly be one and one only; no other will, or we should say can, make good steel. If it be the capability of obtaining any apparatus by which a single definite result can be obtained, always to be relied upon, which will thus give it its commercial value, that value is enormously increased when the working of the apparatus can be so controlled that the primary process may be so modified that more than one resulting product can be obtained. The history of patented inventions affords innumerable examples in proof of this; and that of the iron trade is, as we shall see as we proceed, no exception to it.

The maintenance of a proper temperature in the interior of the vessel in which the ores are reduced in the direct process of steel making,—the form of the vessel in which the mixture of ores and other materials used, technically called the "charge," affecting as it does what engineers term the "behaviour" of the resulting molten or partially molten material while in the vessel,—and the facility with which it may be removed from it at the time and in the way necessary,—and further, the mode by which the vessel is, so to say, freed from the remains of the "charge," putting it in the best state to receive a fresh charge,—are all points of the greatest, indeed of essential importance. More than one process has been wrecked through not possessing one or other or all of these requirements.

Hitherto the kinds of vessels employed for reducing the ores have belonged to, first, the crucible in one or other of its ordinary forms; second, the gas retort or a modification of it; or, third, specially designed vessels. All these have one object in view,—the reduction of the ores in the largest amount, at the least expenditure of time, fuel, and labour, and the securing of the conditions necessary to produce a metal or metallic material of a known and definite character and quality; but the result of using such vessels is not always one—the one demanded or required.

It is not only the form or shape of the vessel which decides the precision with which the process is carried out and economically worked, but its mere position has a great influence upon those points. While it can scarcely be said that one position is that which will alone give the desired result—for two positions may equally well—it may, however, be said that there is but one position in which a vessel can be easiest, that is, most economically worked. There are other considerations also, such as those of humanity: those processes which impose the least tax upon the powers of enduring fatigue, discomfort, and even pain, obviously occupy a higher position in the ranks of good engineering and mechanics than those which can only be worked at the expense of suffering or of toil—even, as in some cases, at that of both. Take, for example, the case of the brassfounder's furnace and crucible. No one of education who has practically worked at it but must have felt that its method was scarcely consistent with, or at least up to the requirements of modern mechanical science, to say nothing of its low standard of efficiency where the comfort of the worker is concerned. Given the furnace, which does possess the evidence of design, and the crucible and its contents, with the object they have to serve, also showing design; the method of working both is neither more nor less than that which man in his lowest stage of civilisation would do. The crucible is taken out and put in with such an amount of pure brute force as is required, and at the expense more or less of brute discomfort or suffering. A parallel example is met with in our present method of warming our railway carriages by means of what are called "foot warmers"—a method, be it noted, which is a standing ridicule and reproach to our much-talked-of inventive powers, and but one step removed from—is indeed the first step—of mechanical design. A savage, with his calabash and a supply of hot water, could do no more than this; certainly he could do no less. Considerations such as these are of value to the mechanical student and reader who is studying in order that he may work, or working that he may study, and both that he may advance in his calling,—of value no matter what may be the practical trade to which he is directing his attention, or belongs. For they involve the first principles of the highest class of mechanical design, which aims at getting the greatest amount of work at the least expenditure of human labour, toil and suffering.

THE DOMESTIC HOUSE OR HOME PLANNER OR DESIGNER.

THE WORK OF THE YOUNG ARCHITECT OR BUILDER IN THE DESIGNING OF HOUSES FOR TOWN AND COUNTRY.

CHAPTER X.

At the conclusion of last chapter we named our intention to go into the two systems of constructing street houses. That promise we now propose to redeem. The two systems are the English and the Scottish—which latter, however, is essentially French, the Scotch having borrowed it from France at that period in the history of their country when the closest and the most cordial and friendly relations existed between it and France. No better exemplification, indeed, of the Scottish system can be met with now than in Paris, old and new, where, in the middle-class houses, a Scotchman might easily enough fancy that he was in one of his own towns,—although it must be confessed that in the way in which the accommodation was *planned* he would find a somewhat considerable difference. And the suggestive remark may here be made, while on this point, that it is curious how much can be learned of the habits and customs, or of the mode of household life of a people, by closely studying the general principle upon which their houses are planned or arranged, and perhaps also just as much, at least in great measure the same, in the way in which they are fitted up and the kind of character and the conveniences of the house. The young architect and builder, if the opportunities be presented to him, should make this point a study or matter of close observation; it will not only in itself afford much that is practical and suggestively useful to him in his profession, but it will lead to outlets even of a much more useful kind. It is impossible for a professional man to know too much of all matters connected with, or bearing even most indirectly upon his calling; and knowledge is easy to carry, and is in no sense a burden, but a help and delight.

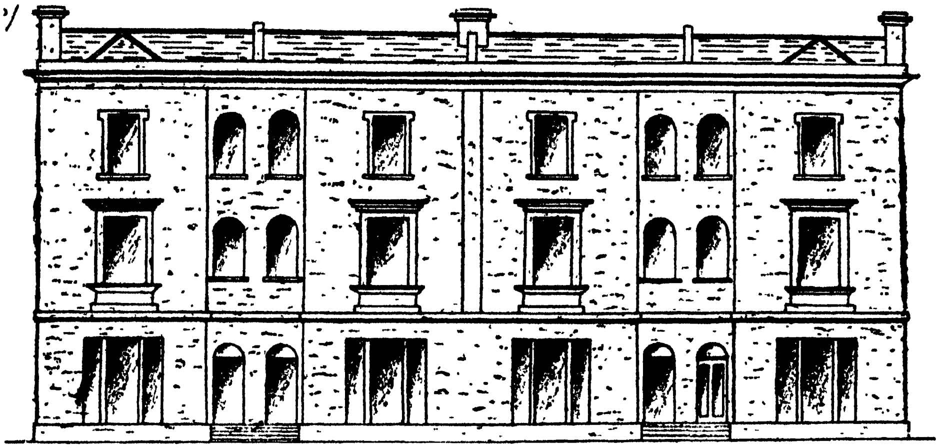
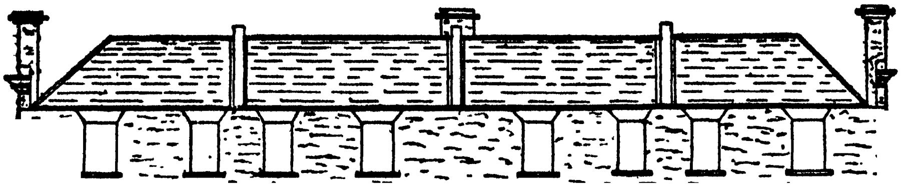


Fig. 5



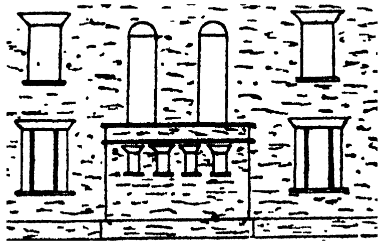


Fig.

Fig, 7.

Detailed Explanation of "the Flat" System of Building Street Houses.

This examination we are now about to make into the characteristics of the English and the Scottish system of street house construction or mode of arranging the accommodation is necessary, not merely because that in an important part of the kingdom we shall have readers directly interested in the matter, but because there is at present considerable attention being paid to the Scottish system with a view to introduce it into England. And it is a curious circumstance in connection with the street house architecture of London, that while so much has been said against the "flat" system of Scotland, the present and latest agitation is for an introduction of it *there*, no doubt with certain modifications which, to those who know of the peculiarities of the Scotch houses, it must be confessed are greatly required.

A paragraph or two will describe the two principles of construction. Taking first London houses—and indeed it may apply with nearly equal truth to the English system of building or rather planning—it may be described as the "vertical system," in which one set or class of apartments is placed above another, beginning with the working and cooking ones, which are placed on the basement, and ending with the "attic" or garret under the roof, in which are stowed away all sorts of "lumber," with which frequently are classed the servants, who have their sleeping cribs or boxes there—for to dignify them with the name of bedrooms would do *in*dignity to this class of apartments. Now, all these different "slices," or strata, if they may be so called, of apartments placed or superimposed one upon another are connected together and reached from one to the other by a stair common to them all. This is enclosed with more real sarcasm than is perhaps designed or understood by many a "well-hole," lighted at and from the top by a skylight; the separate and contiguous flights of stairs being separated by an opening more or less wide to admit the light of this from top to bottom. Now, one obvious result of this arrangement is that the different classes of rooms—as dining, drawing, and bedrooms—with their rooms *en suite*, as the case may be, placed on the different floors of the vertically arranged house, being inhabited or used for different purposes, the domestic service required by those who live in them involves of necessity an enormous amount of labour on the part of the servants of the house, who live below the whole—that is, in the lowest apartments of the vertical series. It is not easy for those not thoroughly acquainted with the interior daily life of a London house and household to have any conception of the fearful amount of work entailed upon servants by the mere running up and downstairs to attend upon the parties on the different floors. Perhaps the most striking instance of this is to be met with in a good lodging-house. Some of these houses are situated in streets once fashionable and still comfortable and good—as, for example, some of those running down to the Thames from the Strand; and in their construction they are infinitely superior to nine-tenths of the wretched structures of the present day, having been built when building was done honestly; and as regards roominess they are also superior, ground-rent not then having assumed the high proportions to which it has now attained. Well, in one of those large and handsome—for they are so—houses running up to five and six floors, the work of the servants who live and cook in the basement is simply slavery. We have known of one in which the waiting maid has had to take up a hundred and forty different meals in a long day. It seems incredible, but we believed it to be the fact; many of those services would, of course, only be to the first floor, but many to the top floor. Contrast this with the horizontal or "flat" system, in which each house has all its apartments on one floor. Here the labour of *interior* service is confined to one level, and is therefore reduced to a minimum, the distance from the kitchen to the living apartments being that only to be traversed, while there is of necessity a compactness of arrangement which in itself gives the least amount of labour in doing the work. And, be it remembered—which by many is too often forgotten, and by more not known—that of all domestic labour that involved in running up and down stairs is the most fatiguing. Let any one consider the physiological points connected with this lesson, and they will see how this is as we have said.

The Stairs in Common to all the Houses as a Characteristic of the "Flat" System.

The "flats" being one above the other, and attainable by a stair common to them all—and hence in Scotland known as a "common stair"—it is here where one of the chief faults of the system lies, for the inhabitants must walk up and down the stairs to reach the house and the street, or *vice versâ*. Further, the stair coming within that curious category of everybody's property, the cleaning of it is too frequently the work of nobody, and we well know the natural result of this arrangement.

In Paris and other Continental towns, in Brussels, Vienna, Hamburg, etc., etc., the "flat" system is also adopted; they have, however, adopted an arrangement by which the inconveniences—if a worse name could not, as it well might, be given to them—of the common stair are quite obviated. This is by having the entrance to the stair, and by consequence the whole interior of the house, wholly under the control of what we should call here a housekeeper or porter, but who in Paris goes by the name of the "concierge."

PLANS OF STREET HOUSES: ELEVATION IN FIG. 2, PLATE CLXII.

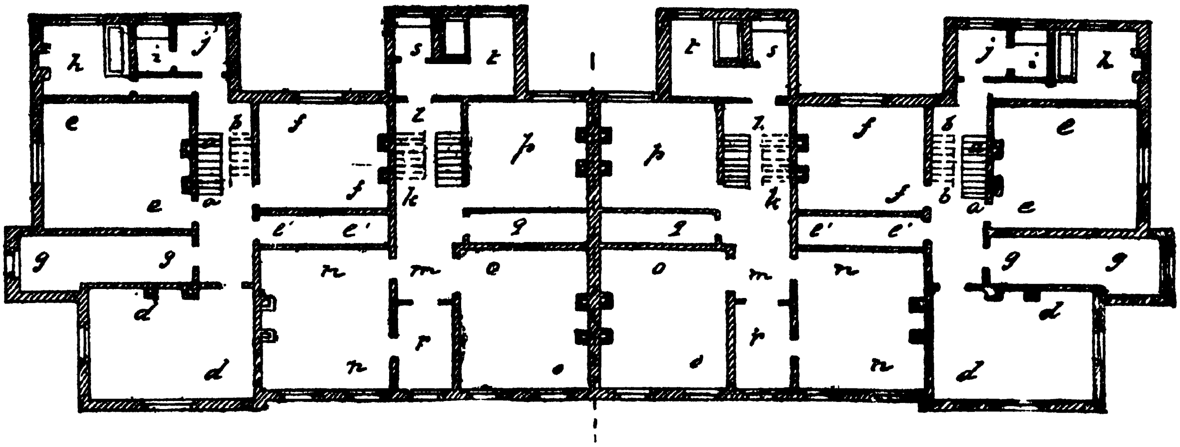


FIG. 1.

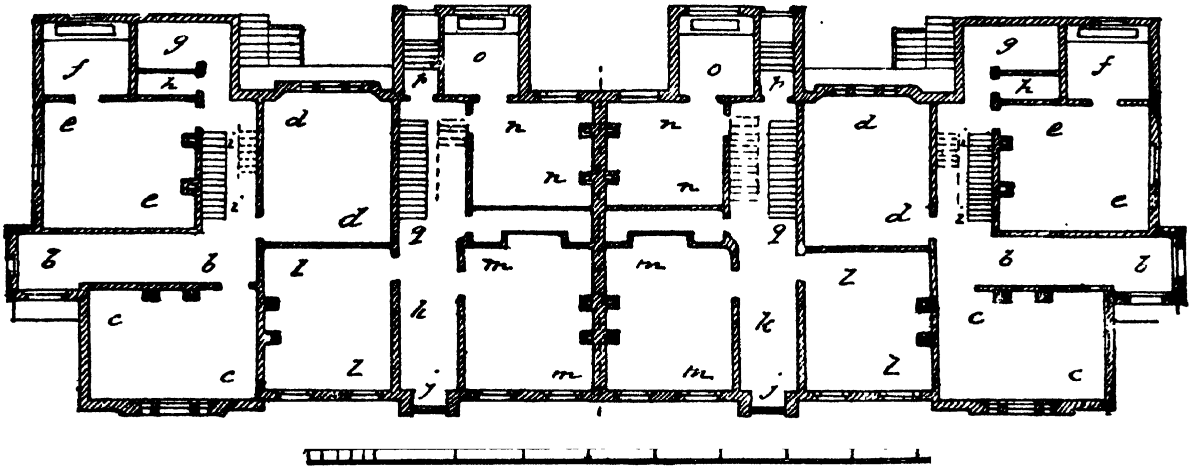


FIG. 2.

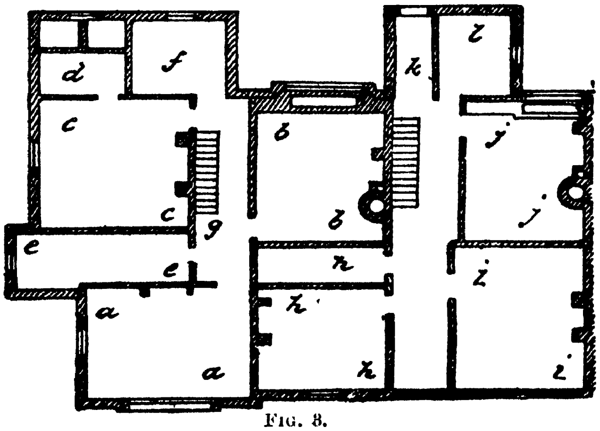
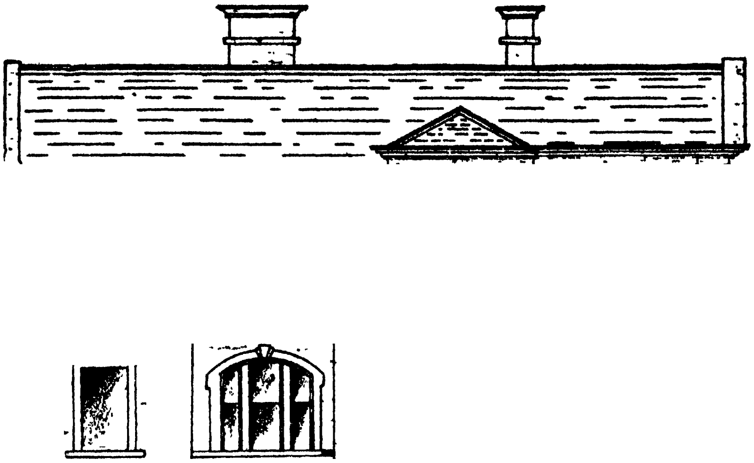
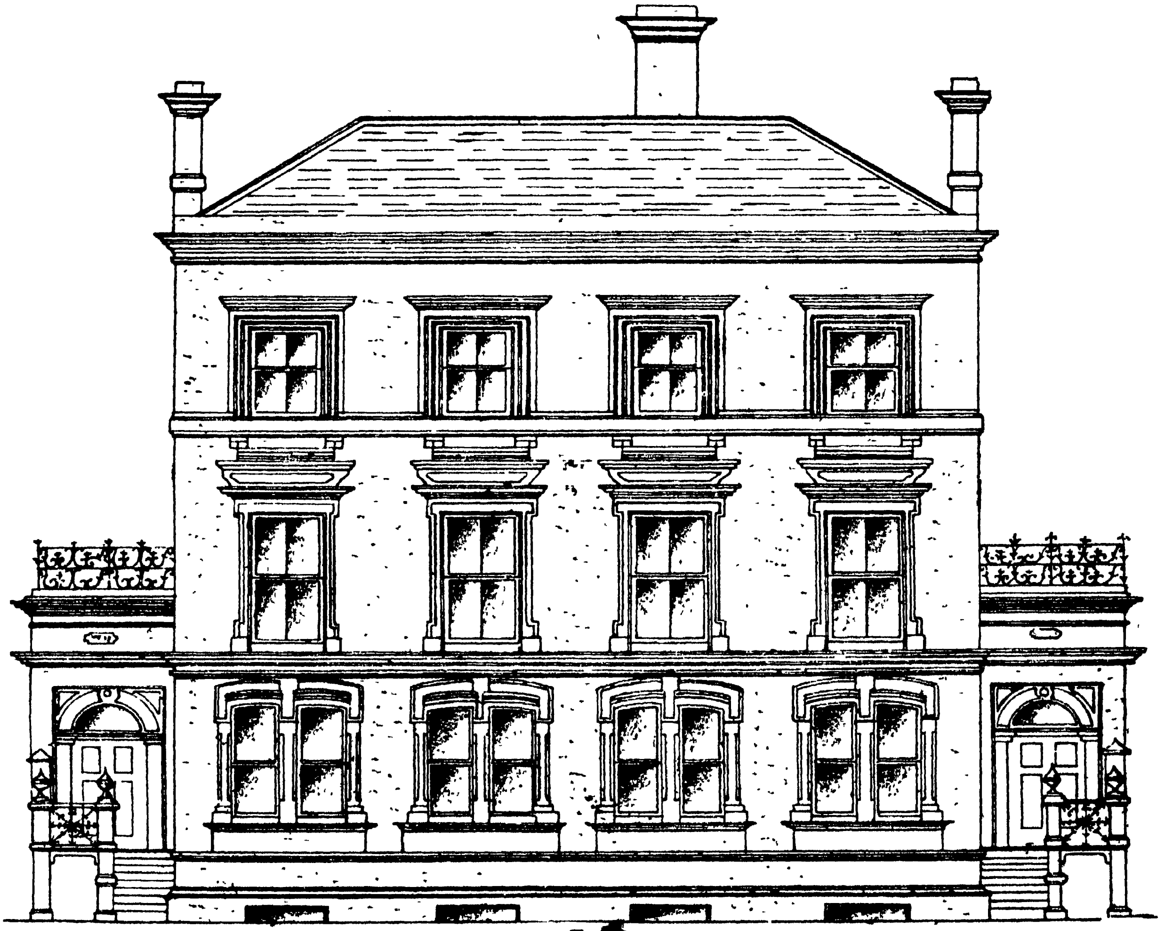


FIG. 3.

THE DOMESTIC HOUSE PLANNER.



G. 1.



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THE STONE MASON.

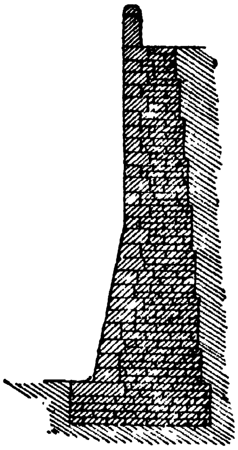


FIG. 1

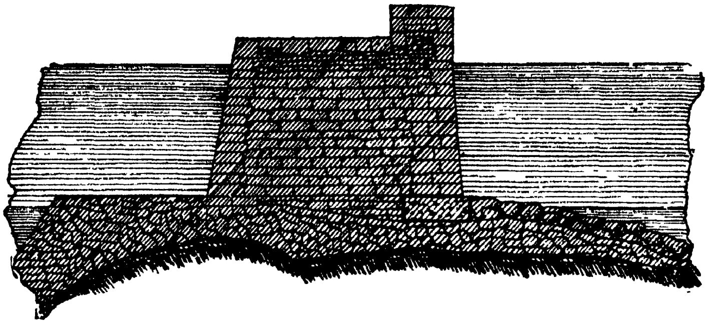


FIG 2.

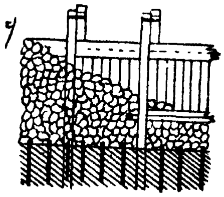


FIG. 3.

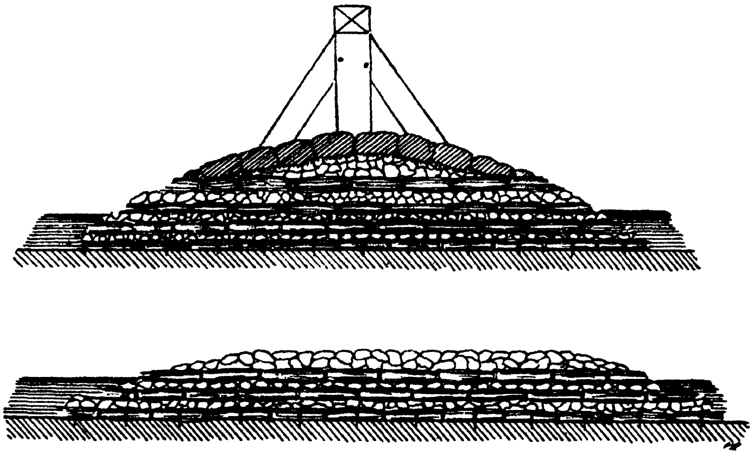


FIG. 4.

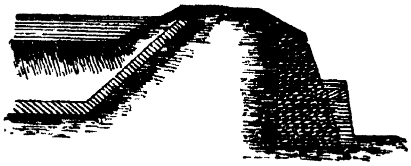
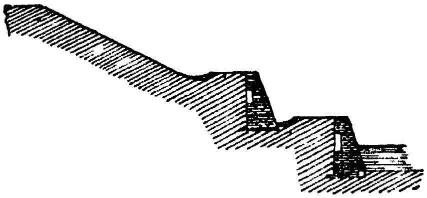


FIG. 5.



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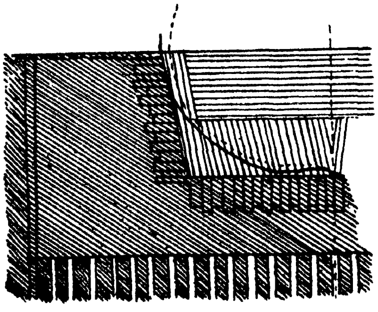

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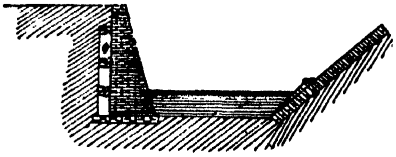

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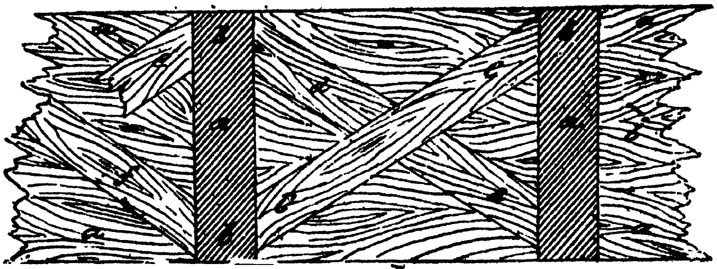

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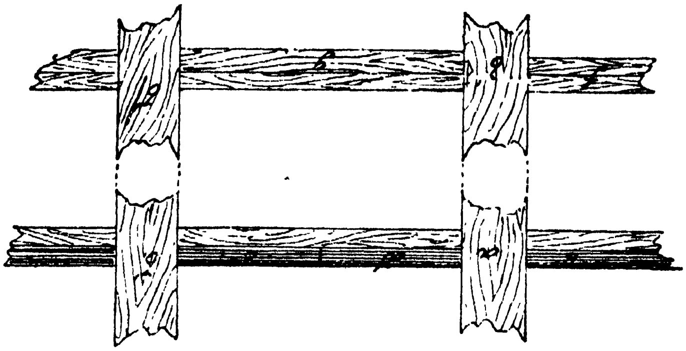

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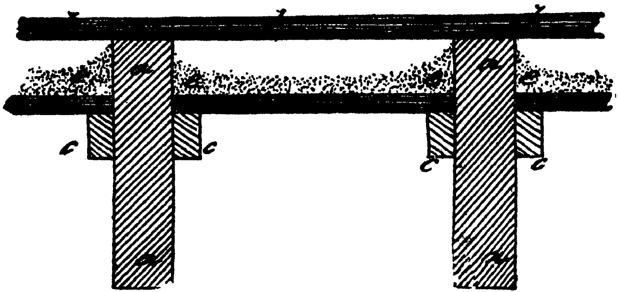

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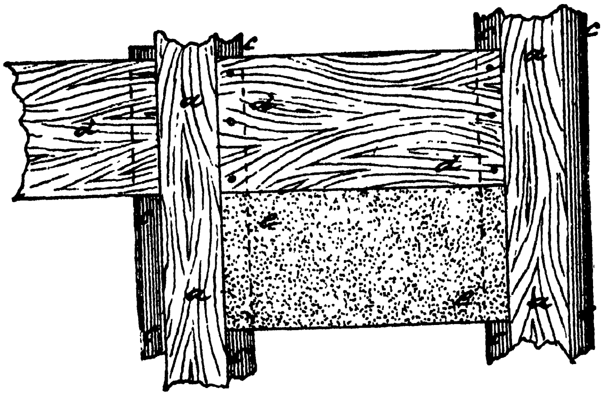

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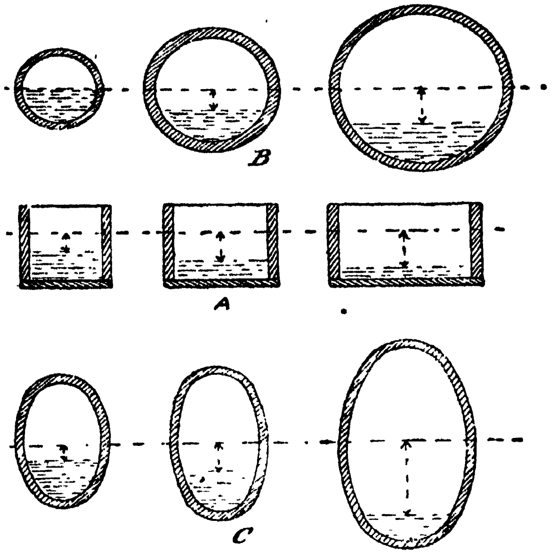

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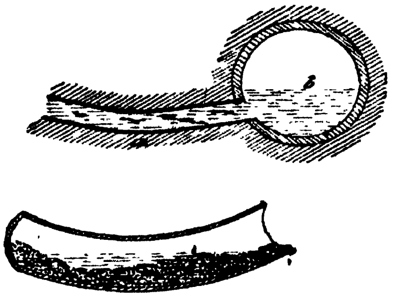

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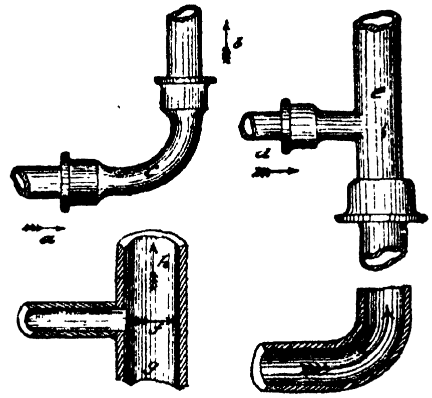

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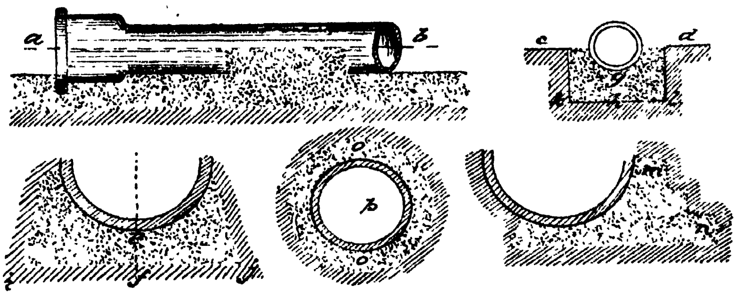

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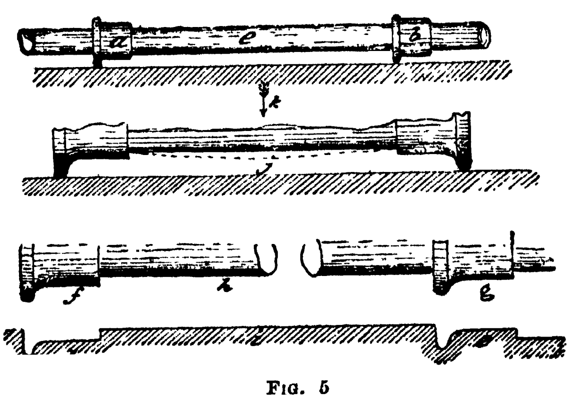

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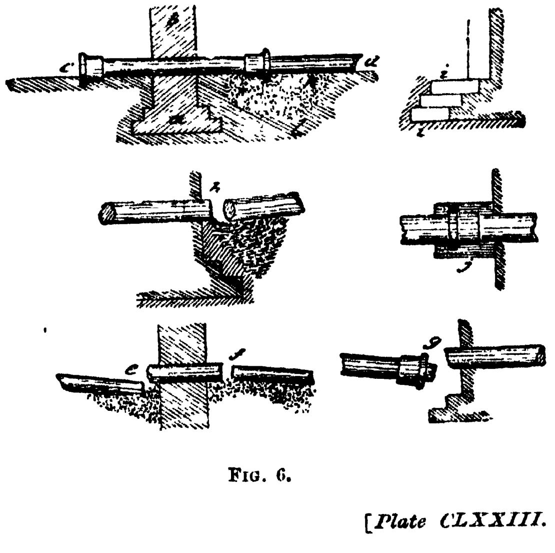

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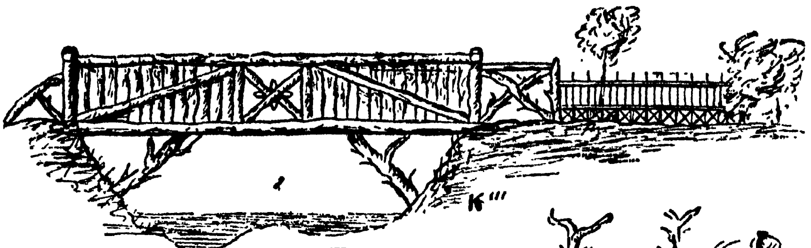

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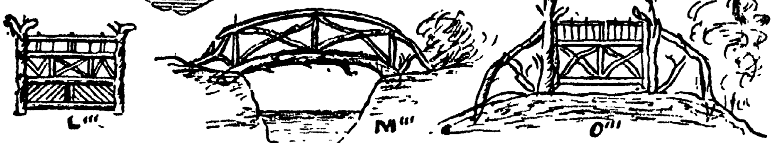

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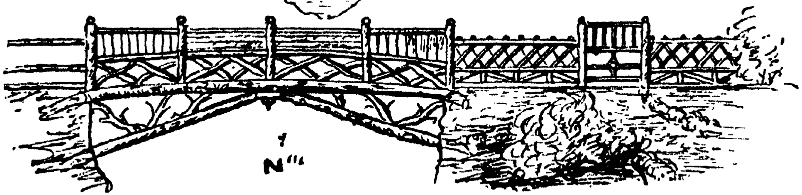

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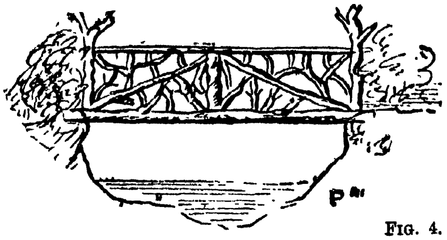

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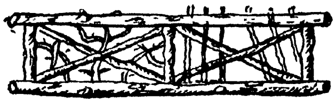

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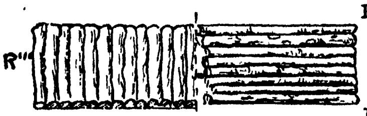

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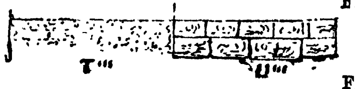

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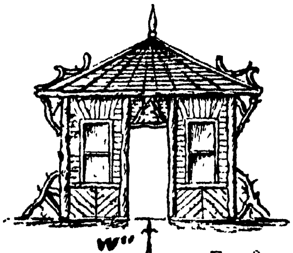

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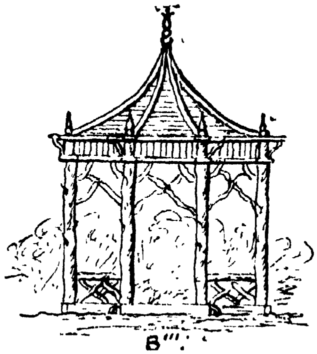

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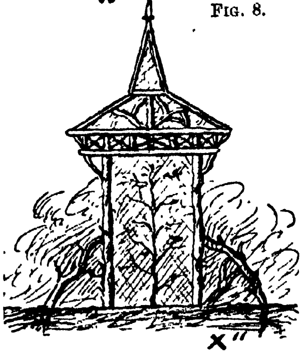

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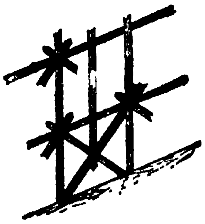

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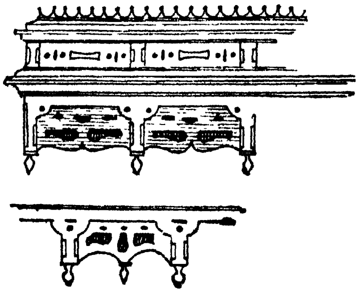

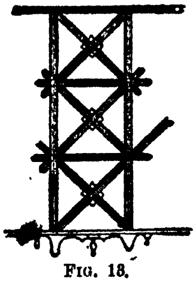

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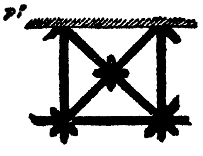

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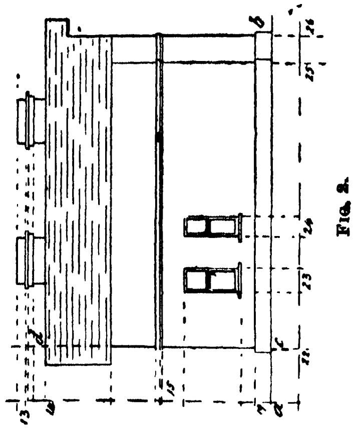

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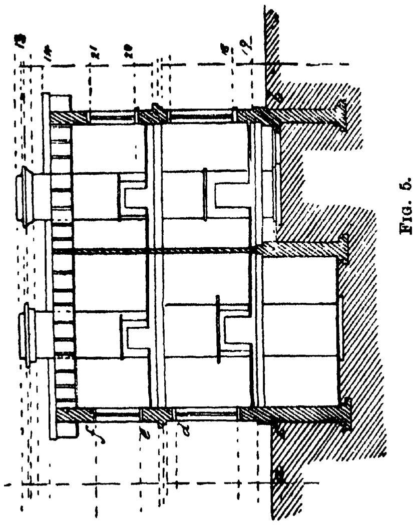

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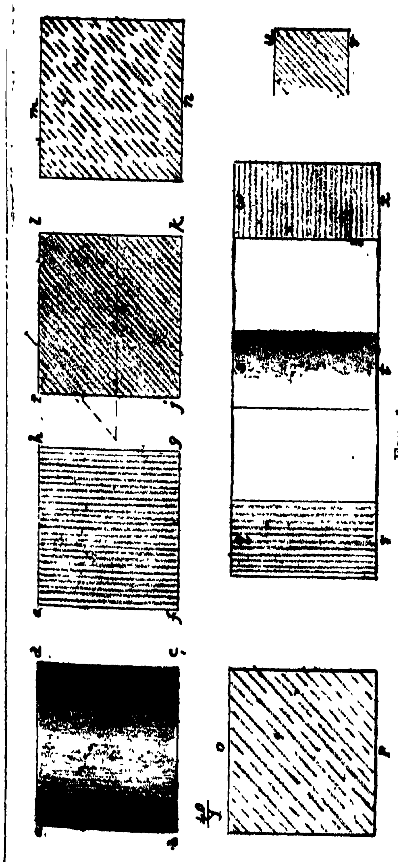

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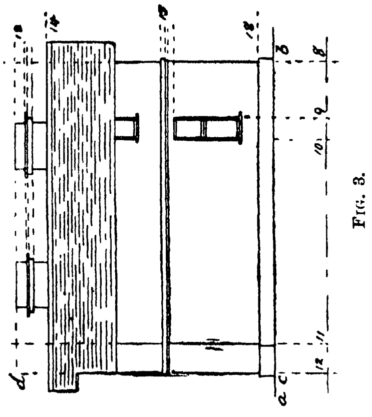

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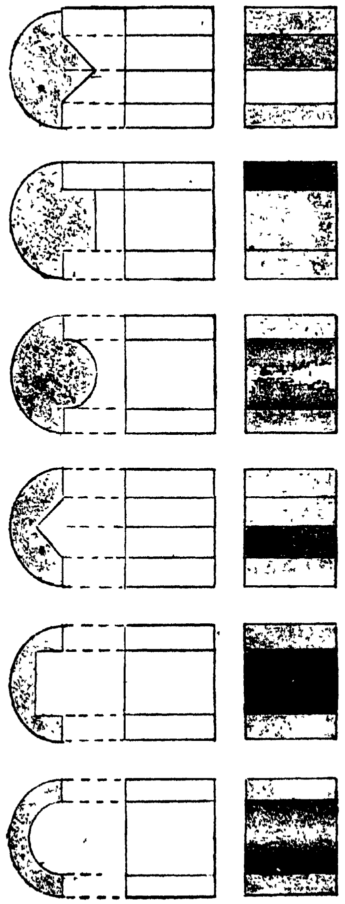

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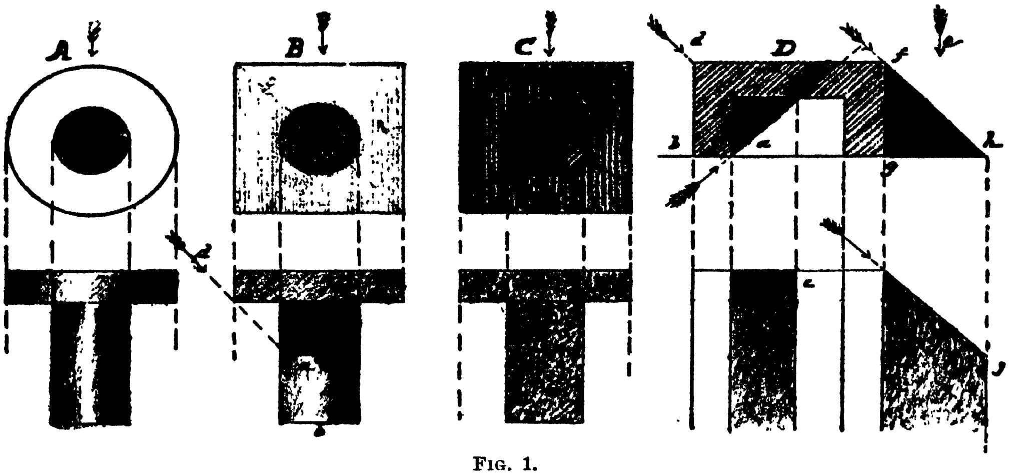
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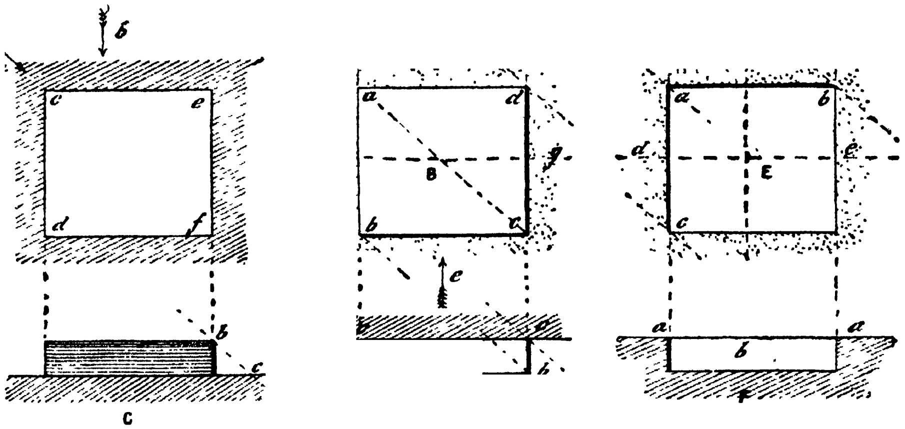
Fig. 1.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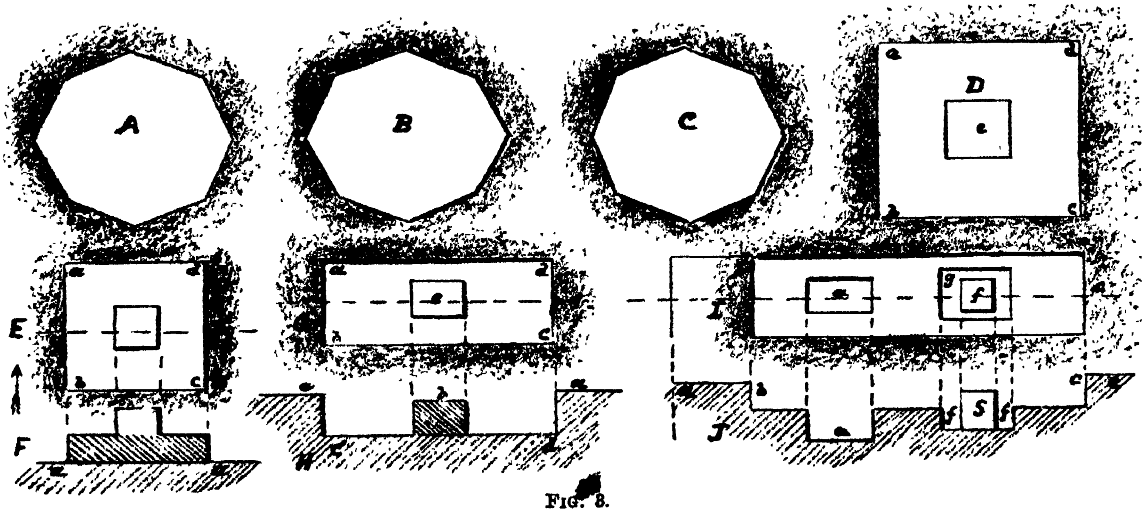
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Fig. 3.

THE ORNAMENTAL DRAUGHTSMAN.

His Study and the Details of its Practice, chiefly in Relation to Technical Work in Manufacturing Design.

CHAPTER XVII.

We have now to introduce our pupil reader to a further and a higher stage of his art—that of shaded subjects. Hitherto his work has been confined to subjects in which the effect was obtained by lining only. In the higher department lining or outlining is still of the highest importance, but the effects of light and shade are to be added to the subjects.

Shading.

Before entering upon this subject, it will be well to treat slightly of the materials the pupil is to use, and also as to the different methods of using them. And this the more especially as these matters are but seldom touched upon in those works on drawing in which we might reasonably expect to find something concerning them. Most young aspirants to artistic fame are sorely puzzled, in examining a finely finished chalk drawing that has been done with the point, to account for the peculiarly brilliant effect, so soft and yet so distinct, which such drawings possess. Lithographs have an effect somewhat similar, and it appears to the youth natural enough that "printing" should bring about such a result; but how it can be managed by the hand, and with such simple materials, he does not see so clearly. It is with the purpose of enabling him to understand this that we give the following details.

In the first place, the fineness of effect in a chalk drawing depends very much upon the paper. Every kind of *paper* is not suitable. If the surface be too roughly granulated, it is impossible to produce a brilliantly toned delicacy of shadow; if too smooth, it will not "take" the chalk at all. As in water-colours, so in chalk drawings, it is absolutely necessary to choose paper of a given quality of granulation, or success is entirely out of the question. In making his selection, we would advise the pupil to avoid by all means the common smooth cartridge, buyable for twopence the sheet. We have found Whatman's Imperial, at sixpence the sheet, exceedingly suitable, *not* hot-pressed—a process which simply does away with this granulation. There is a paper specially made which has the exact amount of granulation which fits it for its specially intended purpose, and the purchasers may rely upon its excellent lasting qualities. Directions for sketching the subjects upon the drawing-paper chosen have already been given in the chapter on the first elements of Freehand Drawing.

Chalk is sold in two forms. You can get it in small sticks for use with the porte-crayon, or buy it in wood, made up after the fashion of a black-lead pencil. The former is the better when you are stump-drawing, and require a quantity of dust quickly produced; the latter is decidedly preferable in point-drawing. There are two shades of black chalk buyable. No. 2 is a deep soft black, and is generally used for blocking-in the rough broad shadows of subjects. No. 1 is finer and harder, and is also generally employed for the lighter shadows, and for filling up, by stippling, the interstices left by No. 2. But in our practice we should recommend the student to work his drawing all through with No. 2, beginning and ending with it. Our reason for this recommendation is, that by using No. 2 lightly the student can obtain all the delicacy of No. 1. The using of the two numbers is apt to mislead the student, and make him think that fineness of finish is the object to be aimed at, in place of expression of form, which is really what constitutes the value of his work. We wish to impress this most distinctly upon the student, in order not only to save his time, but to prevent him falling into the vices of meretricious style, which, whatever may be its claim to be considered finished work, is far removed from what constitutes truth of form. The student must ever bear in mind that the finish in chalk is but the means: expression of form is what he is to look for. Whether the drawing be coarse or finely finished, if the form be not expressed, the drawing is worthless. Of the absolute truth of this let the student rest assured.

The French chalk pencils are undoubtedly the best; and of these the sticks marked "H. C. A., Paris," are to be preferred. They are almost universally adopted in the Government Art Schools. You can purchase them for twopence the stick, both our Nos. 1 and 2 being the same price. The quality of the chalk in these pencils is, however, rather uncertain, and there is no method of distinguishing a good one from a soft or gritty one but by using it. It by no means follows, though, that because a stick starts badly, it is bad all through; in fact, the opposite is as frequently the case as not. The grit will be found in many of them to have penetrated but a short distance, and the remaining part of the stick will turn out excellently. In using a gritty pencil, we would advise the student to continue cutting it until the grit or the stick is entirely gone.

A word or two as to the forming of the chalk point. If money be of any importance, the sharpening of the pencil deserves some consideration. A good point is likewise essential to the doing of the work properly. The student must not grasp the pencil in the left hand, and hold it from him (as we have seen some art students do), and then, with the knife equally firmly held in the right hand, whittle away at it, giving to the point no support at all. The almost certain result of adopting this careless way of making the point is that there will be no end of breakages, and consequently no end of expense. We have seen a stick free from grit cut through in half a day after this foolish fashion. The best mode of getting a good point we proceed to explain. Take the new stick in the left hand, and hold it between the thumb and first finger. It will then rest in a part of its length on the second finger. Grasp the knife in the fingers of the right hand, and press the stick against the right-hand thumb, which is left free. Then begin cutting about three-fourths of an inch above the end, and very gradually form the point by careful and delicate use of the knife, leaving the chalk bare about a quarter of an inch. After you have done with the knife, take a small, thin, and very fine file, and very cautiously file down the point to the required degree of delicacy. In the use of the file great care is necessary. The pencil should be held still in the left hand, its point resting *in its whole length* upon the soft flesh over the extreme phalange of the first finger. The thumb, which is free, will turn it round as the file goes over it. It will not be necessary to file the point where only rough broad shadows are required; but when you wish for extreme delicacy, whether in stippling or hatching, we heartily recommend this to be done. For all that is necessary in work, the knife will be sufficient; the student, therefore, should from the first accustom himself to its use.

It will not be necessary to give any lengthened definition of what is meant artistically by the term "shading." The pupil will easily understand that by the shaded portion of an object we mean that part of its surface from which the light is either wholly or partially excluded. The dark side of the figure is its "shaded" side, or that portion of it from which the light is shut off. It will not need much explanation, either, to enable the pupil to understand that not only does one part of an object exclude light from some other part of it, but the object itself shuts off the light from some other object; or, as it is termed, "casts its shadow." By way of illustration, take a lighted candle, and put it close to the hand, in a room otherwise dark. The hand is not only shaded on the side opposite to the candle, but it likewise "casts its shadow" upon the wall in the shape of itself. We recollect the fine use which Wilkie has made of this fact in the conception of his "rabbit on the wall." Another fact for the student to remember is, that reflected light has enormous influence upon shadows, and the truly fine artist is the one who most clearly evinces his knowledge of this influence. By reflected light we mean that light which, being thrown by one object upon another, is transmitted thence forward to some other surface. As an example, take a book in the left hand, and place it between yourself and the window, so that you look upon its shaded side. Then take a piece of white paper in your right, and hold it so that the rays of light which fall upon its surface may be reflected or thrown back upon the said shaded side. It will immediately be perceived that this latter becomes lighted up; and this will be the case in proportion to the light receiving qualities of the object which casts the reflected light. One of the finest examples we know of the treatment of reflected light is in Rembrandt's painting of "The Burgomaster." The burgomaster is reading a letter, with his back turned to the window, his left elbow resting easily on the window recess. The light falls directly upon the letter, and is cast thence upon the face, which is thus relieved from what could not have been, but for this, other than a sombre, gloom-filled shadow. There is a marvellous play of reflected light and shade upon some of the antique statues—in, for example, "The Dancing" or "Clapping Faun." If this cast be placed underneath a light from the top of the room, so that the rays may fall on it at an angle of 45°, our meaning will be seen clearly enough. An attempt at explanation without the cast would be tedious, because of its complexity.

Another principle which the student must take an intelligent note of may be stated thus:- *Gradation of shade* produces the appearance of roundness or projection. Thus, the globe or sphere, as in fig. 1, Plate XLIII., is not only a geometrical circle, but it looks also like a globe; or in other words, one part of its surface seems nearer to us than the other, its centre representing the limit of the prominence towards ourselves. Take the chalk pencil, or any object with a rounded surface, and examine it with the view of finding out the reason why, without touching it, you understand it to be round. You will notice at once that it cannot lie either in the body, colour, or the outside form; for an object with square edges, and of the same colour, would have a precisely similar appearance without the gradation of shadow. Its roundness of look is the result of a regular deepening of shade, which, starting from the high lights, is continued in the same ratio of gradation to the dark parts of the figure. An examination of the drawing will give the pupil a better notion of what is meant than any amount of description in words. Let the pupil take an egg, and mark the influence of this principle upon its shadows, and he will instantly be able to make further practical application of the rule under consideration. It will not be necessary to enter more fully into this general subject of shading here. In the first place, we have said enough about it to enable the reader to comprehend fully our subsequent instructions. We earnestly advise, however, that the sketches in figs. 1 and 2, Plate XLIII., receive the pupil's best attention, as the remarks which follow on the subject of chalk shading will presuppose a thorough acquaintance with the principles there illustrated. The remarks which have just been made concerning gradation of course imply that there are different depths of shade.

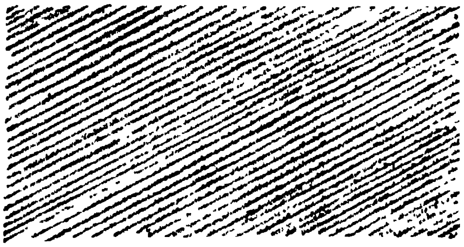


Fig. 61.

The shade immediately joining the high light, in the figure of the sphere or globe in fig. 2, Plate XLIII., the pupil will see is different in degree from that towards the lower part of the sphere's circumference; and it is necessary that he should be able to express various depths of shade—slight, medium, and intense—over an extended surface with regularity and evenness, before proceeding to try gradation. For unless he can produce a flat shade—as, for example, the side of a rectangular object in fig. 2, Plate XLIII.—which shall be equal in intensity over a given surface, he can never expect to succeed with a graduated shade, which demands for its perfect expression fine feeling and most delicate handling.

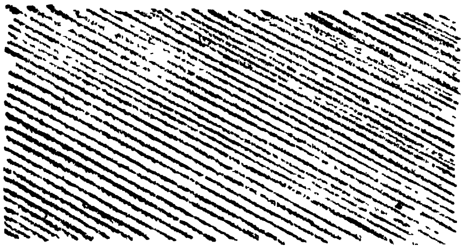


Fig. 62.

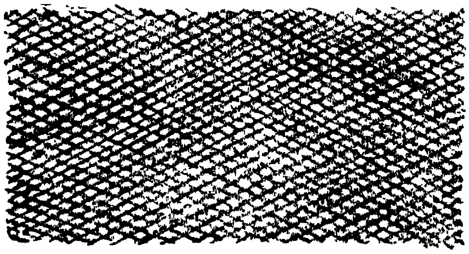


Fig. 63.

Let the pupil take the rectangle, fig. 61; draw within its boundaries, taking a No. 2 chalk, a number of extremely fine lines in any direction, as in the sketch. Then, across these, at an angle—see fig. 62—let him draw other lines of similar fineness, and with the same distance between them, giving the effect as in fig. 63; then sharpen his point with a knife to as extreme a delicacy as he finds possible, and fill all the remaining interstices in the square by stippling or pointing, as in figs. 64 and 65. In doing this the pupil must be very careful not to let his point encroach upon any of the lines, or the result will most probably be unevenness, the thing he is specially to guard against. Let him use the point to dot, point or stipple up every untouched portion of the surface of the figure, until he can find no part which has been left undone. Now let him make an examination of his attempt. Probably enough, there will be much to find fault with. Some portions of the surface will be lighter than others, and most likely his first effort at stippling has mainly resulted in small, black, irregular patches, which *will* show themselves. Do not let him permit this, however, to dishearten him, but let him draw surfaces of the same depth of shade, and he will at length be able to produce one tolerably even or uniform in surface.

Fig. 64.

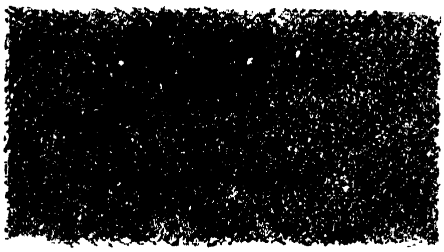


Fig. 65.

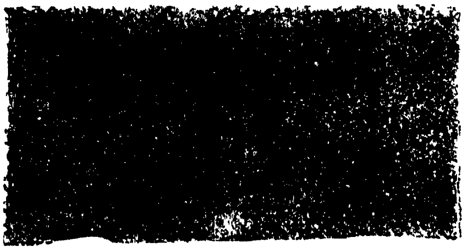


Fig. 66.

Figs. 66, 67, 68 and 69 show different degrees or tones of shading. It will be understood that figs. 61, 62 and 63 show the successive steps taken in getting the groundwork of the shade.

THE TECHNICAL STUDENT'S INTRODUCTION TO THE GENERAL PRINCIPLES OF MECHANICS.

LAWS AFFECTING NATURAL PHENOMENA—MATTER AND MOTION.

CHAPTER XX.

Illustrations of the Centre of Gravity of Bodies as influencing their Stability or the Mechanical Security of Structures.

We have seen that the terms "central point," "balancing point," "centre of weight" and "centre of gravity" all mean the same thing, but that the latter is the established or universally accepted term. There is, however, another term which is synonymous with those now named: this is the "centre of inertia." The reason for this the young reader will perceive when he considers what we said in commencing our remarks on this subject of the centre of gravity: that this central point of bodies is that point to which, if a force be applied exerting upon it a certain influence, that influence is exerted upon the whole body or mass. If, for example, that force suffices to move the central point of a body which is at rest, and to set it in motion, it sets the whole body in motion; just as, conversely, if the central point of a body which is in motion is influenced by a force or power or energy which stops it, it stops or arrests the whole mass or body. The young reader may have a difficulty to see at first sight that this must theoretically be so, and it is necessary that he should understand the point. Nor are we, in saying this, overlooking what he may advance—namely, what can be the use of saying anything about applying a force to the central or balancing point of a body, seeing that that point is enveloped, so to say, in a mass of matter or molecules so that it cannot be reached? This objection, in point of fact, is in one way a sound, indeed a common-sense one, inasmuch as in practice, in everyday work, when we apply a force or use a power or develop an energy to move a body, as in putting out muscular exertion of our own body upon it, this application is made externally—that is, we place our hand upon the outside of the body or mass to be moved—and that, even if we would, we could not reach to or get at the central point of the mass. So that (our young reader may go on to say) it would be more to the purpose if we said that if we move the outside part of the mass or body we move the central part, or what we have said is the centre of inertia, as also it is the centre of gravity. All this is quite true; nevertheless we say that it is necessary that the young reader should comprehend what we have stated: that in affecting the centre of inertia or gravity—the two being, as we have stated, synonymous—we affect the whole mass or body. For this, he will see presently, is that which affects the whole of the phenomena of the stability of constructions dealt with by the community: that it is the relation, as we have already stated, which the central point of a mass or its centre of gravity bears to the whole mass, and to the base upon which the construction or body stands, that affects and brings about its stability or otherwise. We proceed now to show how this is so, taking up, in the first place, the points affecting the stability of bodies at rest or stationary.

Illustrations of the Centre of Gravity as affecting the Stability of Bodies at Rest.

We may safely take it for granted that there are but few who would not be able at once to say which of two bodies was the more stable or secure, or, to use the popular phrase, firm—one of which was broad and low, the other narrow and very high. Of those two bodies we seem, as it were, to know intuitively that the tall or narrow object, as *a b c* in fig. 9, would be more easily overturned, as we should say, than the broad and low object, *d e f g*. We shall see presently that this term "overturned" carries with it what will make some of the theoretical points connected with the subjects now being considered easily and practically understood. Stated generally, the stability—or steadiness, to use the popular phrase—of any object which we suppose in our illustrations to be placed upon, standing or based upon the ground or earth surface, depends first upon the fact whether its centre of gravity or balancing point is well within its base or foundation; which condition involves what may be in itself the second condition of stability—namely, that in which it is a difficult thing to turn over or change the position of the centre of gravity from its normal position within the base or foundation; so that it is changed to a position beyond or outside of the base. It will be seen presently that the one of those two conditions involves the other, and that as a consequence, when the centre of gravity falls or is made to fall beyond or outside of the base, the object or body turns over, and falls, as the popular phrase is. Let the young reader remember what we have said in a preceding paragraph,—that if the centre of gravity of a body be left free to move, as the plummet or ball *t* in fig. 8, when the cord *u v* is cut or loosened from its fastening at *u*, it drops vertically, and this in a direc-

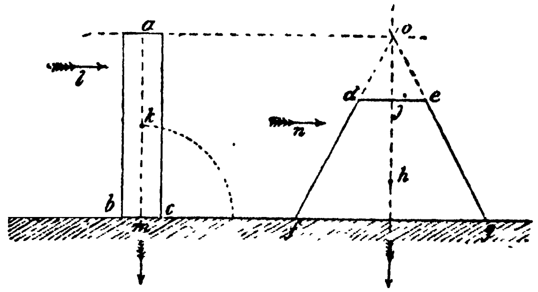


Fig. 9.

tion tending to the centre of the earth, and that with the movement of the centre of gravity the whole body or mass moves. Assume now that the point *h* in fig. 9 is the centre of gravity of the body *d e f g*—which in form or shape is what is technically termed a "truncated pyramid" (see "The Geometrical Draughtsman"). This is obviously well within the base *f g*, and it also lies low. We shall see presently how this position of a low centre of gravity, which is obviously nearer the base *f g* than it is to the top *d e*, as the distance on centre line is less than distance *h j*—makes it a difficult matter so to act upon the body that its centre of gravity shall be turned over or changed from its normal position *h* on the centre line—which is the line of natural gravitation—to a position on either side of it so far that it will get beyond either the point *g* or *f*, that is, outside of the base. Take now the object to the left in fig. 9, and assuming that it is of equal section throughout, and of homogeneous material throughout, this will place its centre of gravity in the middle of its height, as at point *k*; this throws it as far from the base *b c* as from the top *a*. So long as the centre of gravity *k* remains on the vertical line *m k a*, and therefore within the base *b c*, the tall object will remain stable—that is, it will keep standing vertically. But a glance at the two figures will enable the young reader to perceive that it will be much easier to move the centre of gravity *k* by any force which we suppose to be represented by and acting in the direction of the arrow *l*. so that it will be beyond the point *b* or *c* of the base *b c*, than it will be to move the centre of gravity *h* of the object *d e f g* beyond points *f* or *g*. And this for two reasons: first, that the distance *m b* or *m c* is much shorter than the distance *i f* or *i g*, and therefore the force represented by arrow *l* will have to be exerted for a longer period than the force represented by arrow *n* acting on the centre of gravity *h* of the body *d e f g*. Or if the moving of the centres of gravity of the two bodies or objects *a b c*, *d e f g*, so that they go beyond the base points *b c* or *f g*, has to be done in the same time, the force *n* must be greater than the force *l*. The second reason why the centre of gravity will be more easily moved in the case of the object *a b c* than in that of *d e f g*, arises thus. In overturning those bodies by forces represented by and acting in the direction of arrows *l* and *n*, the objects will move or turn upon the corners *c* and *g*, and the centres of gravity will describe or move along a curve or arc, the centre of which is *c* or *g*. But of these two curves, the path of the centre of gravity or the arc of the body *a b c* is a curve of easy, that is of a falling descent throughout its whole length; the path of the centre of gravity *h* of the body *d e f g* is a rising curve in the first part of its path, before it gets into a falling or descending line. In other words, the path or curve of the centre of gravity *k* of the tall object *a b c* facilitates the pushing over or overturning force represented by arrow *l*; the path or curve of the centre of gravity *h* of body *d e f g* is a resisting curve, so that it has to be lifted up before it reaches or assumes the position of a falling curve. These two points are graphically shown in fig. 10. Let *a b* be the same object as *a b c* in fig. 9; *c* being the centre of gravity, in which position the young reader will observe the whole tendency of its weight is to keep it firm on the ground, pressing on its surface, in its natural tendency to sink into the ground in the direction of the line of gravitation, *c b*. Suppose now the pushing force to come into operation at *g*, and that it pushes the object till it assumes the position at *b h*; the centre of gravity thus falls from position *c* to *d*. The force of gravitation thus acts in the line *d i*, so that the centre of gravity is a little beyond the base. The pushing force at *g* being continued till the object assumes the position *b j*, the centre of gravity has fallen on the curve or path from *c* to *e*, which is far beyond the base; the vertical line of gravitation cutting the base line at point *k*. But not only is the curve *c f* the path of easy descent, in virtue of the centre of gravity *c* of the erect or standing object being high; but the young reader will perceive that the moving of the centre of gravity from the high or normal position *c* to lower positions, as *d* and *e*, is facilitated by the action of gravitation coming into force in another direction. Thus, in the position *h*, the portion of the object outside of the vertical line *d i*, in virtue of its weight, has a tendency to gravitate or drop downwards, as it is free to fall. (like the plummet or weight *t* in fig. 8, *ante*,) when its cord *u v* is cut in the direction of arrow *l*, fig. 10. This action of gravitation is still more pronounced when the object *a b* is pushed by *g* till it gets into the position of *j*, when nearly the whole weight—shown by shaded lines—of the body acts in the direction of gravitation shown by the arrow *m*. So rapidly do those two causes begin to act, that shortly after

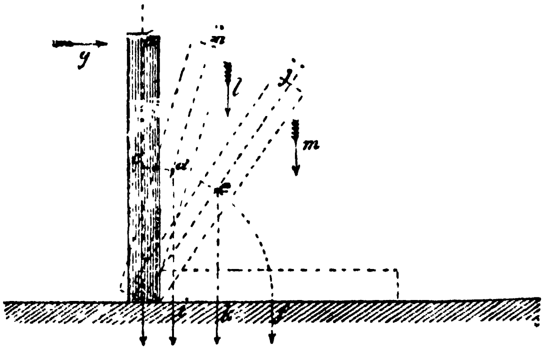


Fig. 10.

the pushing force *g* is exerted, the object falls prostrate, as at *f*.

Illustrations of the Centre of Gravity (*continued*).

Turning now from the diagram in preceding figure, which illustrates why it is what is called an unstable object—and which the young reader has almost intuitively felt to be so, though *why* he did not, as we assume, know—turning from this to the diagram in fig. 11, which as intuitively he feels to be a stable object, or one which popularly described will have a firm position, he will see how completely the conditions are changed. Here, as before—see *d e f g* in fig. 8 (*ante*)—we have a body with the centre of gravity, *a*, low, or near the solid ground on which the body is supposed to rest, the pushing force represented by arrow *b* tending to turn the body over, moving on the corner *c* as a centre, gives a rising curve, *a d e*, as the path of the centre of gravity *a*. It will take, therefore, a considerable force to move the centre of gravity from position *a* to the positions at *d* and *e*; and even when it *rises* as high as point *f*, the vertical line of gravitation dropped from it falls within the base, as shown. If the young reader will go back again to fig. 10, he will remember that with the falling curve or path of centre of gravity of the object there illustrated, the weight or gravitating power of the body began to act very quickly, as shown in the dotted line parts at *h* and *j*. But in the more stable object in fig. 11, now being considered, this weight or gravitating action of the body is for a considerable part of the path or curve in favour of the body remaining in its position, or against its being overturned. For take the lower diagram in fig. 11 to represent the position when the centre of gravity has been moved up to point *f* in the diagram to the left, a very large portion of the object, as *a b c*, shown shaded, is within the base *b*, and this portion having its gravitating tendency in the vertical direction, as shown by the arrow *d*; if the forcing-up tendency which is shown at arrow *g* in diagram to the left lifting the corner *h* is in any degree relaxed, the part *a b c* in the diagram to the right will fall. And in pushing the corner *f* further, till the centre of gravity *a* in upper diagram reaches a higher point, as *d*, the portion *d c e* has to be contended with. Hence the great stability of this form. That of the greatest stability is the pyramid, which is formed by extending the sides *f d*, *g c*, fig. 9 (*ante*), till they meet in the point *o*. The form of least stability would be the pyramid inverted. It might be possible to balance this with the point *o* resting on the ground; but it would take very great skill and patience on the part of the experimenter to accomplish it.

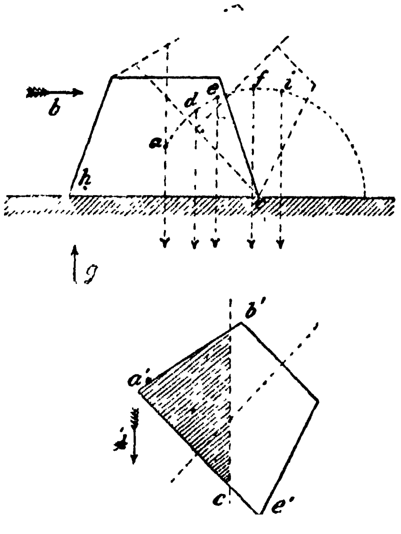


Fig. 11.

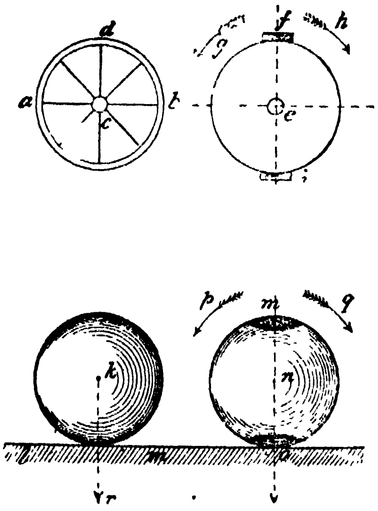


Fig. 12.

The Centre of Gravity of Moving and Rocking Motion.

From preceding paragraphs in this section and that treating on gravitation, our young reader will perceive how it is that the centre of gravity of a body always seeks, so to say, the lowest point, or that nearest the ground, or the surface on which it is placed, whatever that may be, as a platform or the base plate of a machine; in other words, that the centre gravitates in the direction of the earth's centre. This is equivalent to saying that a body comes to the state of rest, supposing it is free to move, when the heaviest part of it gets nearest to its base, or the surface on which it rests. And the peculiarity of the path of motion of a body free to move, and seeking—so to phrase it—a state of rest, depends upon the relation of the centre of gravity to the lowest point which the body can reach, or to the surface of the earth or other surface on which the body rests. Thus, if we have a wheel, as a pulley *a b*, fig. 12, "hung," as the technical phrase has it, or suspended or fixed on an axle, shaft or spindle, *c*, free to move on its bearings, if the wheel or pulley be of equal weight—that is, well balanced—it will rest in any one position which it may be made to assume; as *a b*, or if the point *a* be raised, to *d*. But if to the upper part of the pulley or wheel a heavy body, as a piece of lead, *f*, were attached, as by flexible clips like those used to affix a "fog signal" to a railway bar, the moment the weight *f* was released from the hands and the pulley free to move on its axle or shaft, the weight, and with it of course the pulley to which it was attached, would move round either in the direction of the arrow *g*, or in that of *h*, till it reached the lowest point, *i*, when, after some oscillation like a pendulum, it would there remain at rest; and if the shaft or spindle were suddenly broken, the pulley and weight would drop in direction *j* vertically till it reached the ground or some solid resisting surface. The same would hold true of a solid ball or globe *k* placed on the ground or other surface *l m*, supposing it to be of homogeneous material throughout its mass, as there would thus be an equal weight of material round the centre *k* at all points radial to that centre. The ball would thus be indifferent, so to say, to any position, and would remain at rest in any way it was placed on its base *l m*. But if, as in the case of the pulley *a b*, one part, as *m*, was heavier than any other part, if left to move, this weighted part would seek the lowest point, or would gravitate to *o*, turning round either by the curve *p* or *q*, according as the bias given on releasing the hand, for example, from the weighted part *m*; and this bias or influence due to muscular action would be present, although not perceptible to the experimenter. This arrangement is that of the well known toy which consists of a ball on which a grinning figure is seated. As the lower part of the ball is heavily weighted, as at *o*, however persistently the juvenile pushes it down towards the base right or left, the moment the figure is let go or released it as persistently rolls back to its original and vertical position, and this greatly to the delight of the juvenile, puzzled much to account for the curious movement. The motion which the ball thus arranged as a toy has is called a rocking motion. The rocking motion of a body with a curved base is further illustrated in fig. 13, where the curve in which the body *a b* rests on the ground or surface *c d* is not spherical, but elliptical. In this the line of gravitation from the centre of gravity *a* passes through the point *b*, on which the body rests on the surface, and is therefore at rest. Let us suppose that a force acting in the direction of arrow *e* presses down the end *f* till the body assumes the position as at *g h*. By the force acting on end *f*, the centre of gravity *a* is obviously raised in a curved path. This throws the point of contact of the body with the surface *l m* to the left of the point *j*, which corresponds to *b* on the line *a b*; the weight of the body is therefore now chiefly on the side opposite to the point of contact *k*, and the result is that when the force as *e* is released or taken off from the end *g* corresponding to *f*, the end of the body *h* falls to or approaches the surface or base towards *m*; and is, by the momentum which it acquires, carried so far down on the curve *b n* of first figure, that it assumes somewhat of the position in the third figure where the conditions are just the opposite of those in the second figure—that is, the point of contact *p* of the body is now on the side of line *o q*; hence, as the weight is chiefly on the end *o s*, the body falls from *s* towards *p*, and again the momentum so carries it on that the opposite end *s* rises till it assumes the position somewhat as at *h*. These oscillations or rockings or swingings—as they are by the latter name sometimes called—become less and less decided through the action of friction, etc., with each change of motion, till finally the body comes to a state of rest, just as a pendulum ceases to oscillate to and fro if it be not under the influence of a continued force, as falling weights or a spring. But if the force be applied so as to keep the body, as *a b f n*, in continued and alternate rocking motion, we have a rocking machine or rocker, which may be partially filled with some material which requires to be moved to and fro. It will be obvious that the character of the rocking motion will be dependent upon the character of the curve of under surface, such as *f b n*. If the curve be long, as there shown, the rockings will be slower than if it be short, as at *t u*; and if the height of the body be considerable, throwing the centre of gravity, as at *v w*, high, it will have a great tendency to be overturned, too much of the weight being thrown on the side of the line *w y*, so that it may not be able to take the return swing or rock when the acting force is released.

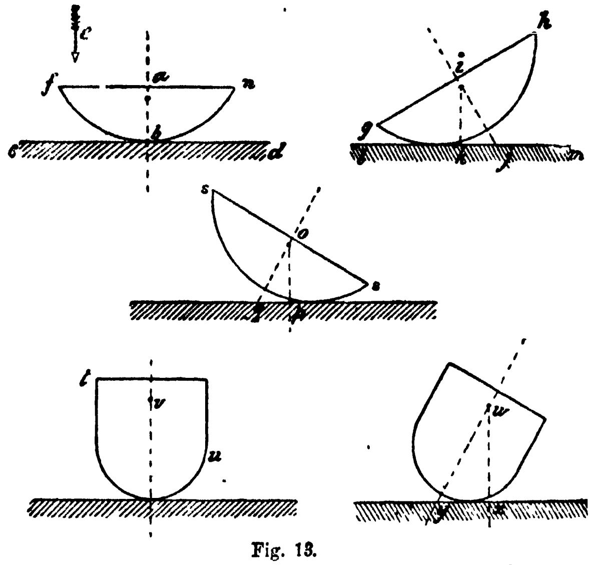


Fig. 13.

THE GEOMETRICAL DRAUGHTSMAN.

HIS WORK IN THE CONSTRUCTION OF THE FIGURES AND PROBLEMS OF PLANE GEOMETRY. USEFUL IN TECHNICAL WORK.

CHAPTER IX.

Through a Point *a*, fig 42, at some Distance from a Straight Line *b c*, to draw a Straight Line which makes with the Straight Line *b c* a given Angle.

THROUGH the point *a* draw a straight line, *m n*, parallel to the straight line *b c*; then from the point *a* draw the two straight lines, *a x* and *a y*, forming, with *m n*, an angle equal to the angle given. These two straight lines are those required, for the angles *m a x* and *a x c*, *n a y* and *a y b*, are equal.

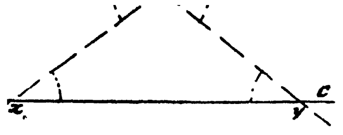


Fig. 42.

To Draw within a given Angle *b a c*, fig. 43, a Straight Line, *a x y*, equal to a given Line *l*, and which is Parallel to another Line, *r s*.

Through the point *a*, the apex of the angle given, let us draw a line *a r* parallel to the line *r s*. Take a distance, *a r*, equal to the given length, *l*; through the point *r* draw a line *r x*, parallel to the side *a b*; this line cuts the other side, *a c*, at the point *x*. From *a*, on the side *a b*, set off a distance *a y*, equal to *r x*. Join the point *x* at the point *y*. The line *x y* is the line required. It follows from this construction that the quadrilateral *a r x y* has its two sides, *r x* and *a y*, equal and parallel; the two other sides, *a a* and *x y*, are then equal and parallel.

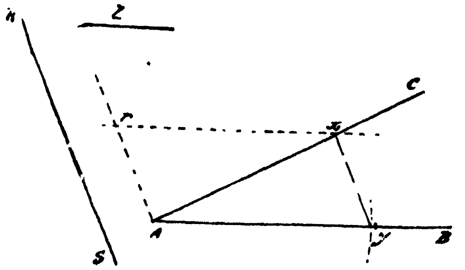


Fig. 43.

From a given Point *m*, fig. 44, to draw Straight Lines the Parts of which between Two Parallels, A B, C D, are Equal to a given Line.

From any point *a*, taken on one of the two straight lines, A *b* or C *d*, describe, with the length *l* as radius, an arc of circle which will cut the other at the points *r* and *s*. Draw the straight lines *a r*, *a s*, and then through the point *m* lead *m* R and *m* S parallel to the lines *a r* and *a s*. The portions P R and Q S, embraced between the two parallels A B and C D, are exactly equal to Z, for they are equal two by two to the lines *a r* and *a s*, as parallels embraced between parallels. There are two solutions. There evidently would not be two if the given length Z were shorter than the distance of the two parallels.

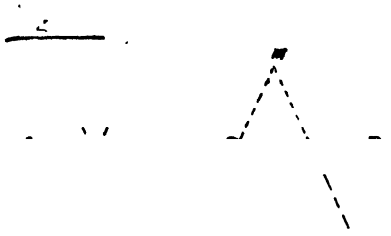


Fig. 44.

To construct an Angle Equal to a given Angle, fig. 45.

From the apex *b* of the given angle *e b f*, and from the given point *a*, describe two arcs of equal radii; make *c d* equal to *e f*; draw the straight lines *a c* and *a d*; *c a d* is the angle required to construct an angle equal to a given angle (fig. 45).

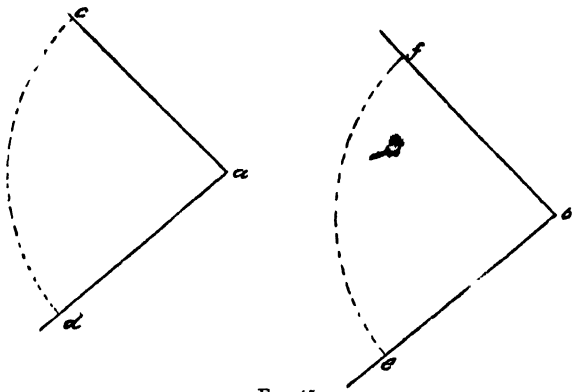


Fig. 45.

To divide a Straight Line into Extreme and Mean Proportion, fig. 46.

At the extremity *b* of the line *a b*, raise a perpendicular, *b c*, equal to the half of *a b*; from the point *c*

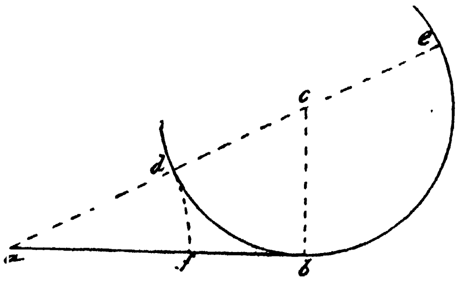


Fig. 46.

as centre, with the radius *c b*, describe a circle, and draw the line *a c*, which will cut the circle at *d*. Take *a f*, equal to *a d*, and the line *a b* is divided in mean and extreme proportion—that is to say, in that of A B : A F :: A F : F B.

To divide a Line, as *a b*, into Equal Parts; for Example, Five (fig. 47).

At the point *a* draw a straight line, *a c*, forming with *a b* any convenient angle; divide this straight line into five equal parts; join the extremity of the last part, at its point 5, to the point *b* of the line *a b*, and to this line draw parallels through all the points of division. These parallels will divide the line *a b* into as many equal parts.

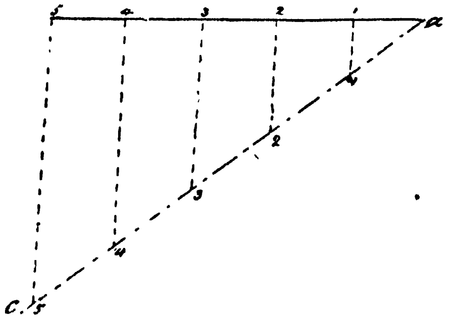


Fig. 47.

The segments determined by these parallels on the straight line *a b* are equal, for they are proportional to those of the straight line *a* 5 *c*, which are equal by construction. The above problem is somewhat troublesome when the geometrical draughtsman has not at disposal any mechanical appliances for drawing the parallels. (See " The Engineering and Architectural Draughtsman.) We give now a construction which is in principle the same as the preceding, but which presents greater facility of execution, and at the same time exactness, when we have only the ruler and compass to work with.

Commence as described in the preceding process by drawing a line A X (fig. 48), on which is set off five times any convenient length. Join the point 5 to the point B. From the point A as centre, with A 5 for radius, describe an arc of a circle which cuts at 5 ; for example, the straight-line 5 B. Draw the straight line A 5, and from the point A as centre describe with radii A 4, A 3, etc., a series of arcs, which give on the line A B points 4′, 3′, etc., equidistant from one another.

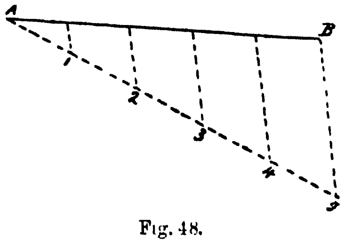


Fig. 48.

Join them as in the diagram. Those lines, which are evidently parallel one to each other, and to 5 B, give the points which divide the straight line A B into the desired number of equal parts.

We give here a third method.

We draw the straight line X Y (fig. 49), parallel to the line A B to be divided into equal parts. On this straight line, X Y, starting from a point O (zero), set off as many times as necessary any convenient length. Join the point O to one of the ends of the straight line and the last point of division 5; for example, to the other end. These two straight lines meet at a point O, which join to the points 1, 2, 3, etc. These lines, 0 1, 0 2, 0 3, etc., determine on the straight line A B points *p*, *q*, *r*, etc., which divide it into equal parts.

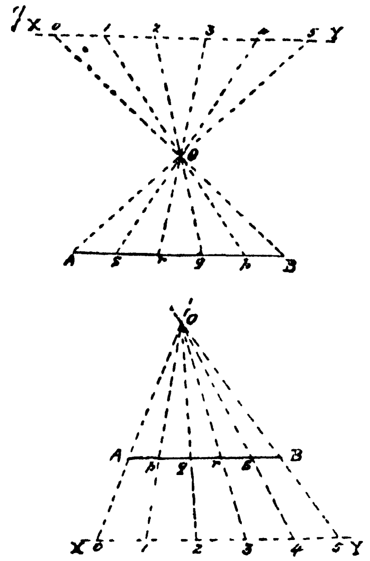


Fig. 49.

To divide a given Straight Line into Parts which are one to the other as Two given Straight Lines, *m* and *n*, fig. 50, or Two given Numbers.

The second case is readily connected with the first, for it is easy to find two straight lines which are one to the other as two given numbers. Let A B be the line to be divided into two parts which are in relation one to the other like the two straight lines *m* and *n*.

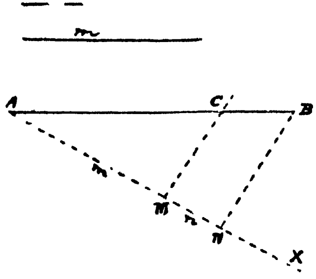


Fig. 50.

THE BUILDING AND THE MACHINE DRAUGHTSMAN.

CHAPTER XVI.

At the end of last chapter we pointed out that the sides of blocks projected might show apertures, in which case these might be shown in the projections or drawings. Thus, a rectangular opening is shown in the side *m n o p*, fig. 31, which we may suppose to be the projection of the house of which we give the pavilion roof, as already explained. How such openings or other peculiarities are projected will be understood, so far as the principle is concerned, by inspection of fig. 32. In this let *a b c* be part plan of a house or other hollow body in which openings, as *d, e, f*, are made in the front line, and an opening *g* at the end, or what is technically called the "return" of the plan. To obtain the position of these openings in the elevation, the same method of projection is adopted, as already fully explained and illustrated in connection with preceding figures. This is shown at *h i*, giving the vertical lines as *j, k, l*. The horizontal lines which terminate at top and bottom the openings thus partly projected, are obtained thus. Assuming those openings to be all "window openings," or "voids," as they are technically termed, the height from "general line" or "base line" *h i* to the "cill" or "sill" of the window void is equal in the diagram to the line *m*, the height to top of void being equal to line *n*. With distance *m*, from point *h* or *i* set off to *o* or *p*, and with distance *n* set off from same points to *q* and *r*. From *q* and *o*, parallel to *h i*, draw lines as *q r, o p*; these will give the bottom or "cill" and top lines terminating the openings or voids at *s* and *t*. The projection of end or return at *b* and void *g* is obtained in the same way, and is shown at *u v*.

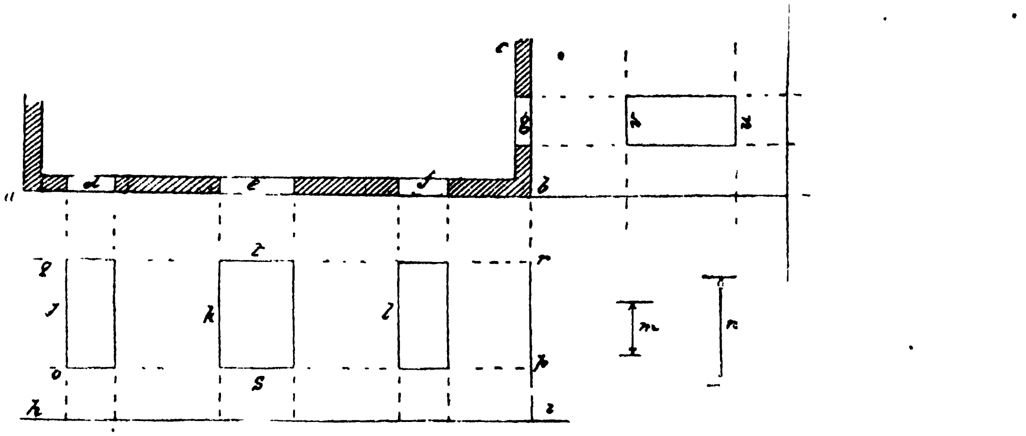
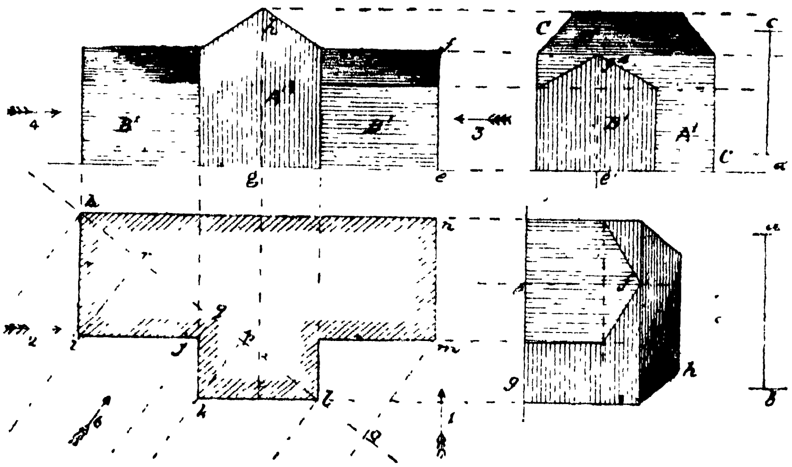


Fig. 32

The diagrams we have thus far given will not only convey to the reader a good notion of the general principles of projection, but will carry with them also not a few practical lessons in the delineation of different views of special subjects. To some of these we have referred, and others will clearly be suggested to the reader on his farther thinking over their peculiarities. We have shown by those diagrams the relations which different views of the same object have to each other, and how these can be made available in facilitating the projection of one view from data obtained in the projection of another view. It will, on due consideration of the diagrams we have thus given, be obvious that an interchange of those relations may be made; so that if the elevation is first projected or if given from its points the plans may be obtained, and so on. As the student-reader cannot have too clear an idea of the various methods adopted in this, and other directions in practice, we give, in fig. 33, at *h i j k l m n*, what may be considered as the "block plan" of a house of which the height of the central part A′ is equal to *a b*, and *c d* that of the wings B′ B′. A′ B′ B′ is the elevation of the side, looking in direction of arrow 1, and A′ B′ of the end, looking in the direction of arrow 2. These projections are obtained from data of the plan in precisely the same way as those projections we have already described; the heights as from *e* to *f* being equal to a given height, as *c d*, and that from *g* to *h* equal to *a b*. It will be observed that the view in diagram C C is an end view looking at the front elevation A′ B B′ in the direction of the arrow 3 or 4, and that this is the same as the end elevation in *e f g h* to the right. In both these views the letters showing the heights correspond with those showing the same heights in the front elevation. This figure 33 gives us lessons in the method of obtaining a diagonal view of the object, to which we shall return in due course after describing the principle upon which the lesson is based.

We have hitherto been considering the projection of bodies of which the plans and the general form have been rectangular, the lines being at right angles to each other. We now proceed to show how the projections of bodies otherwise formed can be obtained. The elevation of a block circular in section or plan, and of height equal to *a b*, fig. 34, is simply a rectangle of which the breadth *c d* is equal to the diameter of the circle *e f*, and the height equal to *a b*; the lines being obtained by producing lines, as *f d*, *e c*, from the points *e*, *f*, the extremities of the diameter of circle cutting a line *c d*, making *d g* equal to *a b*, and joining *g h* parallel to *c d*. In the same figure, the projection of a body in which the plan is a semicircle *i j k* is shown at *l m n o*, which the reader will see is just the same in appearance as the projection at *c d g h*; so that, looked at without the aid of the plans, no definite knowledge could be had as to what they were. In these and in similar cases "shading" comes into use, as to which presently. It will be observed that all elevations of the body circular in plan will be precisely the same, no matter in what direction the diameter of the circle is placed in relation to the circumference. And it is the diameter which decides the character of the projection of the elevation. Thus, if in place of the elevation being as at *e f*, it were as at *p q*, the projecting lines would go in the direction of *p r*, *q s*; if the elevation were oblique, as at *t u*, the projecting lines would be thrown or taken in the direction of *t v*, *u w*. But in each and in all of these cases the projection of "elevation" would be precisely the same as in *c d g h*; for the lines at right angles to the projecting lines, as the lines *r s*, *v w*, *x y*, would all be equal to *e f*. The same would be in the case of the projection of elevation of the body semicircular in plan, as at *i j k*, if the projecting lines were in the direction of *i z*, *k a'*. If, however, the projection of elevation were made in the direction of the radius *j b* or semi-diameter, in place of the diameter *i k* of the semicircle, the elevation would be different so far as the width or breadth was concerned, though the height might be the same. Thus the projecting lines being as at *j d'*, *b' c'*, giving a width equal to *c' d'*—the projection of elevation would be as at *j b' c' d'*, and it would obviously be the same as if the plan were looked at in the direction of the arrow 1, in place of that indicated by the arrow 2.



We have said above that the projections or views of two bodies would present precisely the same appearance, although the bodies would be essentially different in character, as in the case of the two diagrams in fig. 34. Thus the elevation of the body circular in plan, as at *c d g h*, fig. 34, is precisely the same as that of the body semicircular in plan, shown at *l m n o*. In like manner the elevation of *j k* taken on the line *j b'*, and which is shown at *m n*, fig. 1, Plate CLXXV., would be precisely the same if the end, in place of being rounded, as at *j k*, fig. 34, were flat, as at *u v* in fig. 1, Plate CLXXV. It is in such and in like cases that the different methods of *shading* come to the aid of the draughtsman. If the reader will turn to the series of papers in this work entitled "The Ornamental Draughtsman," he will find the subject fully described, and the methods of obtaining the different effects illustrated. Although the methods used by the ornamental, in obtaining these effects, are different from those used by the architectural and engineering draughtsman, the principle or method upon which these effects depend is precisely the same. We proceed to illustrate in simple diagram the conventional methods employed in indicating the character or form of parts of projection or views of different objects by means of *shading*. That the projection or view *c d h g*, fig. 34, in eleva tion, is that of a rounded or a cylindrical body in plan, as at *e f*, is shown by shading it as in the diagram *a b c d*, fig. 1, Plate CLXXV. The shade is darkest at the edges, as *a b* and *c d*, and gradually dies or fades away into the general tone or tint of the paper, or of the "body colour" or "wash" used to indicate the material of which the body is composed—whether that be of wood, stone, or one or other of the metals. But it will be observed (see "The Ornamental Draughtsman," chapter on Shading) that the width, breadth, or extent of the shaded surfaces in the diagrams *m′n′ o′ p′* is different on one side from that which it is on the other, as well as different in depth or darkness. The darkest and broadest shade is always at the right hand of a rounded, cylindrical or convex body, as at the side *c d* in the diagram in fig. 1, Plate CLXXV.; the lightest and narrowest at the left-hand side, as at *a b*. This arises from the principle of shading and the "projection of shadows," adopted by artists and draughtsmen—namely, that the light proceeds to or strikes the plane of the picture or drawing as if coming from the left hand. The left hand, therefore, must be the lightest in shading, as it is nearest the source of the light. But the effect thus produced, as in the diagram of the convex or rounded body in *a b c d*, fig. 1, Plate CLXXV., is reversed in the case of a body concave or hollow: how this is we shall presently see from a succeeding illustration. The view or projection of the semicircular body *i j k* in fig. 34 is shown in diagram *l m n o*, which unshaded is precisely similar to the projection *c d g h* of the convex body *e f*; although this is rounded, while one side *i k* of body *i j k* is flat when looked at in the direction of the arrow 3. If the view or projection at *l m n o* was designed to show the body, as in elevation, it would be lined as in diagram *e f g h* in fig. 1, Plate CLXXV.; or if coloured, would be tinted with a wash or colour perfectly uniform or flat.

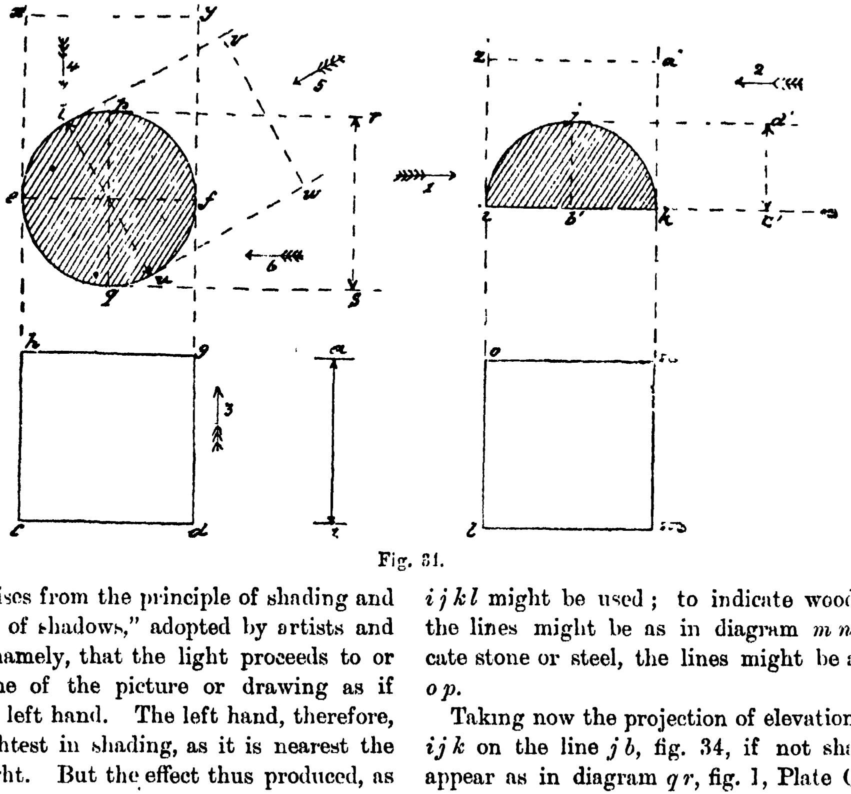


Fig. 34.

If the projection, as *l m n o* in fig. 34, were designed to show the face of *i j k*, looked at in the direction of the arrow 3, it would be finished with cross or oblique lines, as in diagram *i j k l* in fig. 1, Plate CLXXV. This is technically called "hatching," more specifically "cross hatching," by some draughtsmen "cross lining." Those lines proceed generally from the right hand to the left, as in the diagram, and are put in or drawn by means of the "set-square" of 45°. If put in too closely the drawing looks heavy; if the lines be too far apart it gives a coarse look to the drawing. The character of these cross or hatching lines is different in different sections: thus, to indicate one material, as for example brick or brass, the lines in diagram *i j k l* might be used; to indicate wood or cast iron the lines might be as in diagram *m n*; if to indicate stone or steel, the lines might be as in diagram *o p*.

Taking now the projection of elevation of the body *i j k* on the line *j b*, fig. 34, if not shaded it would appear as in diagram *q r*, fig. 1, Plate CLXXV., and it would be precisely the same as the projection in elevation—also unshaded—of the same body, but with the end *j k*, fig. 34, flat, as at *u v* in fig. 1, Plate CLXXV., in place of rounded, while the flat-line projection would be simply as at *q r* in same figure. But the rounded end, seen as when the end *j k*, fig. 34, was looked at in the direction of the arrow 2, would be when shaded as in diagram *s t*, fig. 1, Plate CLXXV.; the shading being confined wholly to the right-hand side, dying or toning down gradually to the main colour of the drawing.

THE STEAM ENGINE USER.

THE DIFFERENT CLASSES OF ENGINES USED CHIEFLY FOR MANUFACTURING AND AGRICULTURAL PURPOSES.—THE LEADING DETAILS OF STEAM ENGINES—CONSTRUCTIVE AND OPERATIVE.—THEIR PRACTICAL WORKING AND ECONOMICAL MANAGEMENT.

CHAPTER XV.

WATT says: "I proceeded to make a model of my method, which answered my expectations; but having neglected to take out a patent, the invention was communicated by a workman employed to make the model to some of the people about Mr. Wasbrough's engine, and a patent was taken out by them for the application of the crank to steam engines. In these circumstances I thought it better to endeavour to accomplish the same end by other means. Accordingly, in 1781 I invented and took out a patent for several methods of producing rotative motions from reciprocating ones, amongst which was the method of sun-and-planet wheels."

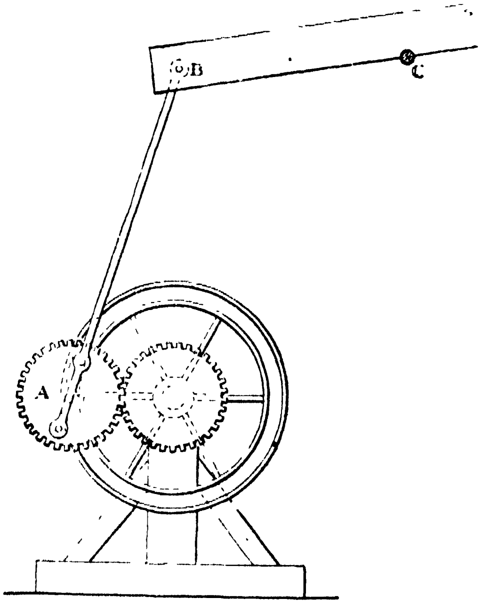


Fig. 29.

Fig. 29 illustrates the "sun-and-planet" motion as published by Watt in his patent specification dated 1781, and which was perhaps his most successful substitute for a crank. In the year 1780 a patent was taken out by Pickard, of Birmingham, for a "new invented method of applying steam engines to the turning of wheels." In the specification it is stated that "a lever, commonly called a crank, is fixed to the shaft or arbor of a great wheel, the pin of the crank being inserted into one end of a spear or carrier, the other end of which spear is connected by a moving joint with the regulating or great working beam, and in some cases to the piston of the fire-engine cylinder." In this description will be evident the arrangement as now generally adopted; but as the crank was only applied to a single-acting engine, it was only available for giving motion to the rotating shaft during the downstroke of the piston, the rest of the revolution being left for completion by the fly-wheel's momentum alone.

Before the introduction of what is known as parallel motion into the working of beam engines, the connection between the piston-rod and the beam was effected by means of a chain passing over an arc on the end of the beam. This form of connection is shown in a previous illustration of Newcomen's engine (fig. 22), and also in fig. 27. Similar connections are made between the beam and the pump rods.

One of Watt's earliest inventions was a combination of levers which enabled the piston to move in a vertical line, and at the same time allowed of an almost direct attachment between the piston and the beam. In the words of the specification of his patent, dated 1784, we read:—

"My second new improvement on steam engines consists in methods of directing the piston-rods, the pump-rods, and other parts of these engines, so as to move in perpendicular or other straight or right lines, without using the great chains and arches commonly fixed to the working beams of the engines for that purpose, and so as to enable the engine to act on the working beams or great levers both by pushing and by drawing, or both in the ascent and descent of their pistons."

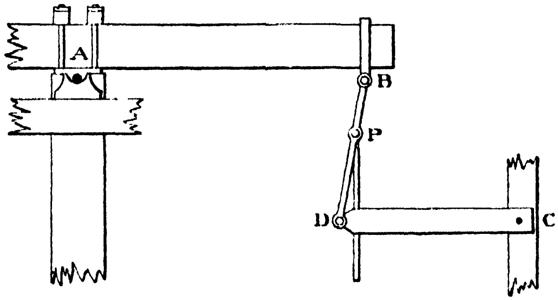


Fig. 30.

The apparatus here described is illustrated in fig. 30. A B represents the beam of the engine, the piston-rod being jointed at P to the rod B D, one end of which is attached to an iron lever, C D, centred on a fixed support at C.

As the beam oscillates, the point B describes a circular arc on the centre A, and the point D describes a like arc on the centre C; and, as Watt himself describes it, "the convexities of these arcs, lying in opposite directions, compensate for each other's variation from a straight line, so that the point P, at the top of the piston rod, which lies between these convexities, ascends or descends in a perpendicular or straight line."

Another form of parallel motion is shown in fig. 31, the various levers being only represented by simple lines. A is the centre of the beam, B C is the main link, D E the radius rod or bridle rod. As the end B of the beam moves up and down on the centre A it describes an arc of a circle. A similar arc is described by the radius rod as the point D rises and falls round its fixed centre E. This rod should be of the same length as half the beam · that is, the distance between the points D, E, should be equal to the distance between the points A, B.

It will be seen that if no such arrangement as this were provided, the strain on the stuffing box and gland of the cylinder would be so great as to seriously injure them and render the joint leaky.

In later years the parallel motion has been almost superseded by a much simpler mechanism, in the form of guides or slide bars, with which there is, of course, more friction; and this becomes a very serious evil in badly constructed engines, with parts fitting indifferently.

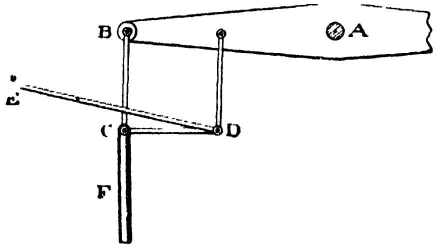


Fig. 31.

We now come to the detached parts of the steam engine.

The piston.—This being a very important part of a steam engine, many improvements and alterations in its form have from time to time been proposed and carried out. Before the time of Watt, a piston consisted of a plain disc of metal made steam-tight by a supply of water being kept on its upper surface. This was sufficient to keep the very low pressure steam from passing upwards to any very serious extent. Watt improved upon this, as we have read, by employing oils, wax, resinous bodies, fat of animals, quicksilver, etc., any of which acted more effectively than water. But by-and-by, when higher pressures began to be used, some other means was found necessary, and the piston itself was made to fit better into the cylinder. In its improved form it consisted of a disc of metal having a groove cut round its circumference, into which rope packing, made expressly for the purpose, was fitted. The packing was platted the exact width of the groove, and a little thicker than the groove was deep,—so that when the piston was placed in the cylinder, which was of a slightly larger diameter inside than the piston, the packing served to fill up the vacant annular space between the two, and having been previously well greased, made the joint steam-tight—so as to permit no steam to pass from one side of the piston to the other. This form of piston packing had its objections, not the least of which was the trouble it caused and waste of time in renewing. It had to be frequently taken out and replaced by new packing. The heat dissolved the grease, the hemp became dry and soon burnt away, and it became evident that something more substantial than hemp must be used in order to prevent the frequent stopping of the machinery for repacking the piston.

Metallic rings were soon substituted for the hemp packing. The piston was made in two parts—the piston proper, and a plate bolted on the upper side called a junk-ring, of the form shown in the accompanying diagram (fig. 32) in which A is the piston and B the junk-ring. A ring was turned to the exact size of the cylinder, and then cut. When cut, such a ring would tend to enlarge its diameter, and thus form a powerful spring. This ring is placed on the piston A, and the junk-ring fixed in its place by means of bolts or studs. The piston is now ready to be put inside its cylinder, in order to accomplish which the spring must first be compressed, when the whole will easily slip into place, and form a close-fitting joint with the cylinder. There is, however, the disadvantage in a single ring that steam will escape between the ends of the cut ring; a second ring was therefore soon adopted, and so placed that the cut portion of one was diametrically opposite the other. By this means the joint was sealed. Sometimes more than two rings are employed, as in the form designed by Mr. Ramsbottom about 1854, in which four rings are "sprung" into position in the grooves turned to receive them in the solid piston. The rings were made of either "brass, steel or iron, drawn of a suitable section to fit the grooves in the piston, and were bent in rollers to the proper curvature, the diameter of the circle to which they are bent being about $\frac{1}{10}$th larger than the cylinder." A most important end attained in using a metallic piston as a substitute for the hempen-packed piston is the reduction of friction, which must have been exceedingly great in the latter form. The rings designed by Mr. Ramsbottom must also be made very light.

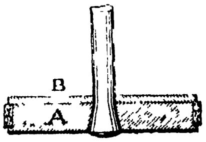


Fig. 32.

THE CARPENTER AND HIS TECHNICAL WORK.

Its Origin and Early Progress—The Principles and Details of its Practice.

CHAPTER XII.

Joints used in Roofing (*continued*).– Junction of Purlins with Rafters.

The purlin in this is notched or grooved into the rafters, but in fig. 61, showing another arrangement, the purlin *a* simply rests on the face of "principal" *b b*, and is supported by a block *a* at its lower end, let into rafter by a tapering notch, as at *a* in side elevation of principal. The block may either be secured by nails to the rafter and the purlin, to prevent lateral movement, or have a key, as *a*, fig. 63, cut in the centre of the notch in face of principal, as at *b*, and in the under side of the block *c*, fig. 61. In fig. 7, Plate VII., *b* shows the form of notch into which the end of the strut *d*, fig. 60, is "housed," as the technical phrase is to indicate when a timber is placed permanently into the part intended to receive it. A simple form of notch is shown at *e*, fig. 60. In fig. 61 *a b' b c'* is end view of fig. 60, looking in the direction of the arrow *e*.

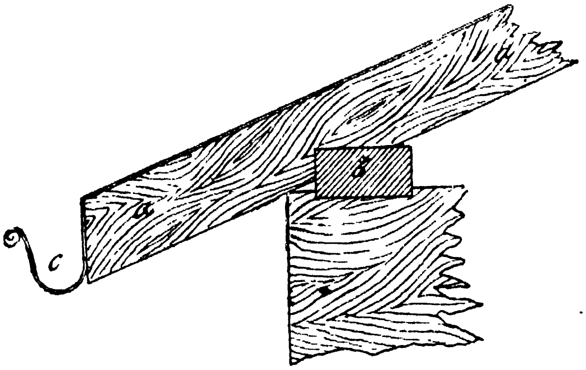


Fig 58.

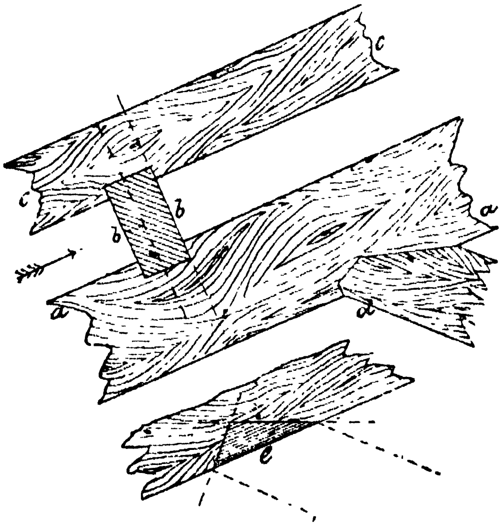


Fig. 60.

Fig. 63 illustrates, in diagram A, methods of connecting feet of rafter *a b* of roof with wall-plates *c d*; *e f* in diagram B illustrates the feet of what is called "ashlets," *g h*, with a wall-plate. The ashlet is a timber used in attic roofs to form at the sides a vertical part of wall surface in place of running the floor right up to the angular space formed by the rafters.

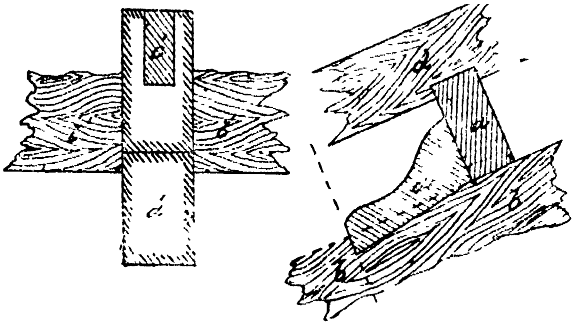


Fig. 61.

Roofing Joints Feet of Principal Rafter with Tie-beam.

The junction of the feet of "principal rafter" with the ends of tie-beams is a most important point of carpentry work. The simplest but weakest way is shown at *a b e*, diagram C, fig. 63, the flat face *a b* of foot, bearing on the upper surface of tie-beam *d*, being prevented from sliding away by the strength of the nails. To prevent this dangerous tendency, the foot of the principal is provided with a butting joint, as *e*, let into a notch cut on upper edge of tie-beam; this butting end, *e*, is strongest when it is made at right angles to the line of principal, as the line *f* to the line *g*; an end section is at *h*.

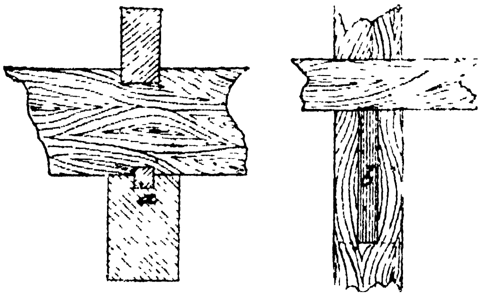


Fig 62.

Fig. 7 (*ante*, p. 12, vol. i.), illustrates other forms of joints of this class. In the form in diagram B a longitudinal mortise or groove, *a*, is left in the centre of the notch in tie-beam *b*, a corresponding tenon or rib being cut in the foot of the principal; *e* is section in line *c d*, *f* cross section of tie beam. Fig. 65 illustrates the junction of collar-beam *a* with rafter *b*, a part, as *c*, being cut out for half the thickness in rafter, and a corresponding part, *a a*, cut in end of rafter of half its thickness, so that the two when joined as at *a b* form a "half lap" joint, as shown in horizontal section *e d* and vertical *f*.

Fig. 2, Plate VII., illustrates the junction of parts in a form of roof hereafter illustrated, *a* being the principal rafter, *b* the common rafter, *c* the purlin, *d* the brace or strut housed at foot into face of tie-beam *a*. Fig. 8, Plate VII., illustrates the junction of purlin in a collar or beam roof: *a* collar beam, *b* rafter, *c* purlin.

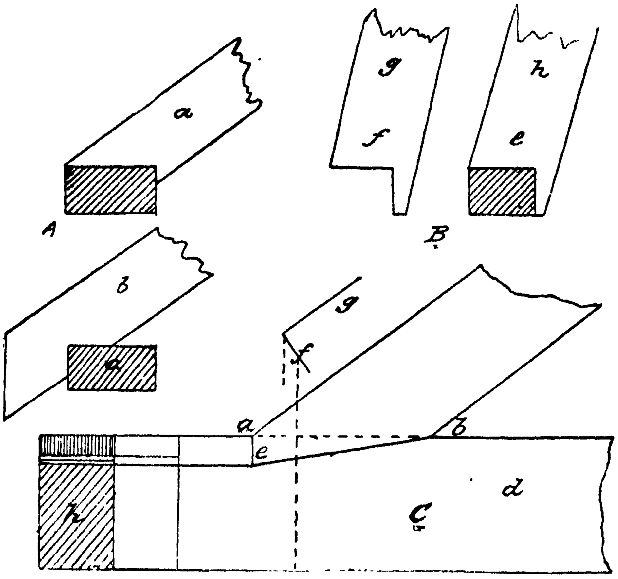


Fig. 63.

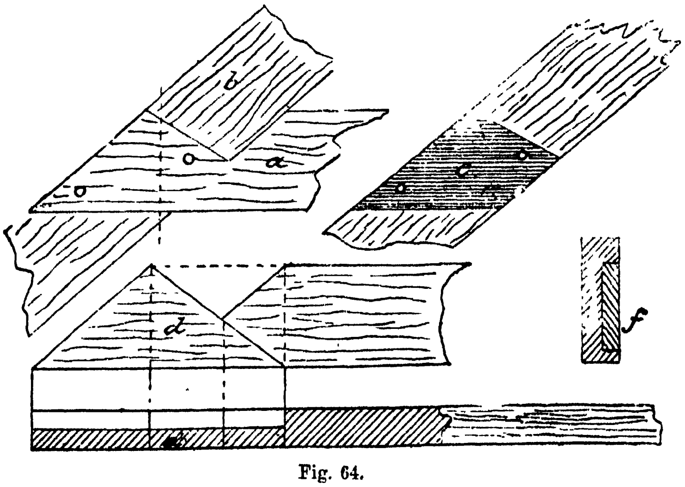


Fig. 64.

Roofing Joints.—Junction of King and Queen Posts with Tie-beam.

The junction of king post and queen posts with tie-beam, straining beams, etc., now comes to be illustrated. In fig. 25 (*ante*) we illustrate junction of foot of king post *a* with tie-beam *b*. this being simply mortised into the tie-beam *c*; *d* shows two joints of foot of brace with the king post in front elevation in diagram. In fig. 4, Plate LXI. (*ante*), we give side or edge view of drawing in fig. 67. In fig. 67, *a a* is king post, *b b* principal rafters framed into ditto, *c c* common rafter butting either simply on end, secured to side or head, or the ridge pole *d d*; *e e* represents the roofing boards on which the slates are fixed. Fig. 5, Plate LXI., in A shows elevation of another method of tenoning end of principal to head of king post *b b*; in diagram B, *a* shows mortise in head *b b*. Diagram C is plan looking down in direction of arrow in fig. 67; corresponding letters indicate corresponding parts. Fig. 26 shows tenon joint of the assemblage of timber at foot of a queen post *a a*, diagram A; *b b* tie-beam, *c* strut or brace tenoned into foot of queen post, which is secured to tie-beam *b b* by tenon *d* and wedge *e*. In diagram B, *d* is part of "straining sill," *e e* of queen post.

THE JOINER.

THE GENERAL PRINCIPLES AND THE DETAILS OF HIS WORK.

CHAPTER X.

Panelled Doors—Names and Offices of Different Parts.—Styles—Rails—Mortises.

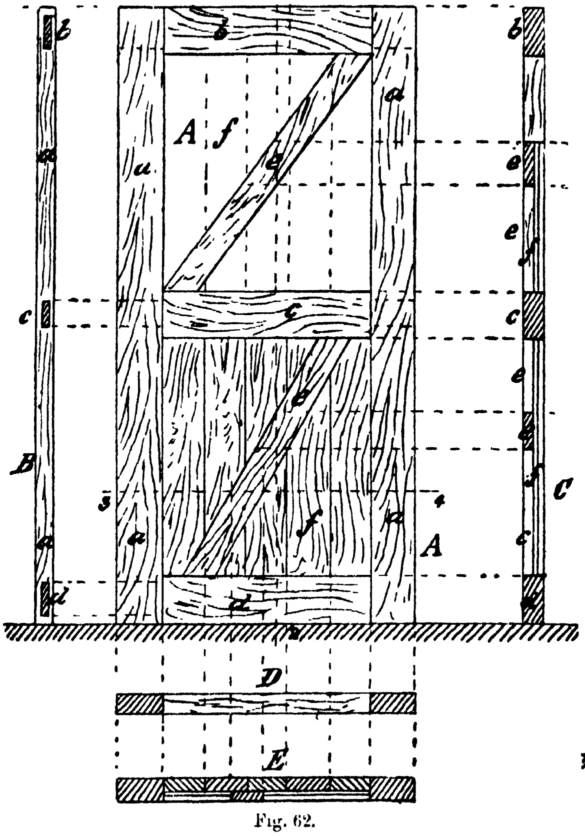
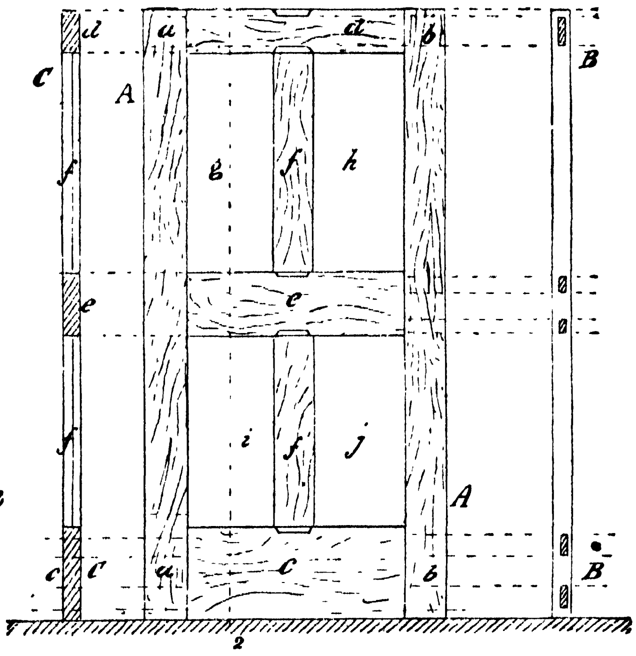


Fig. 62.



THE transition from this form of door to the highest class, the "panelled door," is easy and natural. We have seen in the simplest door, as in fig. 62, the absence of the triangular disposition of timbers, which is the element of the "truss," and which gives the strongest form attainable. In this view the panelled door, as in elevation in A, fig. 63, is not so strong as the form in fig. 62, from the absence of the diagonal braces, as *e e*; but those, if required in a door such as an external one, where strength is an object, can be dispensed with in interior doors, which are always panelled in good houses. Elegance or neatness of arrangement, with such ornamentation as mouldings, etc., can give, are what are looked for. In fig. 63 the external framework enclosing the panels is made up of two side vertical boards, *a a*, *b b*, varying in thickness from 1½ to 2½ inches, and in very superior work even 8 inches. These boards are called "styles"; that by which the door is hung to the casing, secured by hinges, is called the "hanging style," as *a a*; that to which the lock is secured the "lock style," as *b b*. These styles are held together by cross-bars called "rails," of which *c* is the "bottom rail," *d* the "top rail," and *e* the "middle or lock rail." The central vertical bars, as *f f*, are called "muntins" (a corruption of mountings). The assemblage of boards thus arranged leaves spaces, as *g*, *h*, *i*, and *j*; these are filled up with the panels, as *a*, *b*, *c*, and *d*, in fig. 64, which is the elevation of a *four*-panelled door. There are also six-panelled doors. Generally the panels are nearly equal in length, but in some the lower panels are short, the upper being longer. Fig. 2 and 4, Plate XVII., illustrate outside doors in Continental style. The panels are secured to the framing by grooves, as shown in preceding figures, and as further hereafter illustrated, and are ornamented with mouldings, as explained in last chapter. In fig. 63, diagram C is the vertical section; B edge view of style *b b*. In fig. 64, B is plan of top edge of door. The rails are secured to the styles by tenons, sometimes single, but more frequently in good work by double tenons, as in fig. 65, in which A is front elevation of rail, *a a*, *b c*, two tenons. Diagram B is part of style *a* cut vertically in two to show the seats of the mortises *b* and *c*; diagram C, end view of rail. In left-hand diagram in fig. 5, Plate XVII., is elevation of part of "lock style," *a a*, and "lock rail," *b*, of a bedroom door, with simple lock, *c*, known as a "rim lock." In diagram B, part of the "hanging style," *a a*, of this door is given in elevation, *b* part of "top rail"; a portion of upper "hinge" is shown at *c*. Diagrain C is edge view. The inner edges of styles, rails, and mortises are generally, in good work, "stop-chamfered," as at *d d*, or bevelled off from end to end, as at *e f*, the two edges meeting in a "mitre," as shown. The "stop-chamfer," *d d*, is the neatest, stopping, as it does, short of the end. A rim lock is screwed on to the outside of the lock style; what

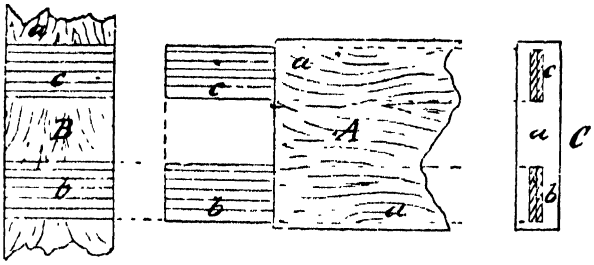


Fig. 64.

is called a "mortise lock" is employed in superior doors, where the lock is to be concealed, nothing but the handle and keyhole being visible; the lock being inserted in the mortise, or vacant part cut out in the style to receive it. Fig. 54 (*ante*, p. 208, vol. ii.), contrasts the two locks. *c d* is the rim lock. In the mortise lock nothing but the handle, as *g*, is seen, and the escutcheon, *h*; *i* is the bolt of the lock; *a a*, *b b*, *a′ a′*, *b′ b′*, are the chamfered styles and rails.

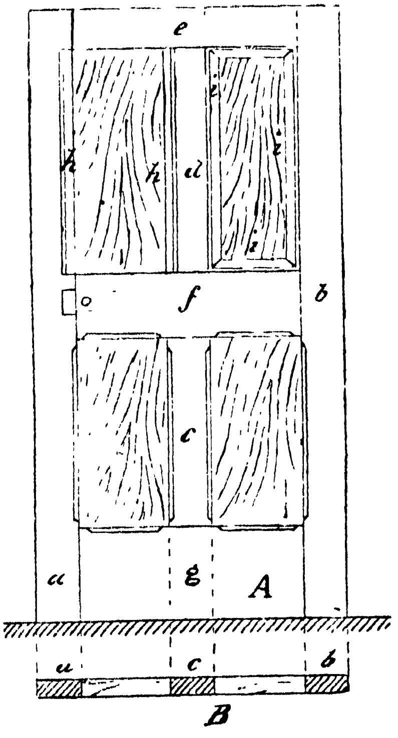


Fig. 65.

Door Casings.

Doors are secured to "casings." These are of timber, and built into the wall, and are secured to wood bricks or grounds. Fig. 66 illustrates in part elevation an outer "door casing." The sides *b b*, *c c*, are called "jambs," *f f* the "head," into which the jambs are tenoned, the feet being also tenoned, at *d*, into the upper part of stone step, *a a*. Fig. 1, Plate XXV., is sectional plan showing arrangement and relative positions of various parts of a door and its casing. The door, *l l*, is hinged to the "jamb" *b*, this being secured to the "ground" or "wood brick" *a a*, built into the wall *b b*; *c* and *j* are the "architraves." The opposite "jamb," *f f*, is rebated as at *m*, to allow of a space into which the door "lock style" falls, as shown by the dotted lines, which represent the lines of the door. The outer edge of jamb may be left plain, but is often finished off with a "quirked bead," as at *j*; *k k* hinge. The inner and outer architraves are at *c* and *j*; *a a*, the wood brick; *b*, the wall; *e*, *i*, are the elevations of the architraves, *d* and *h*. The elevations of these two parts of sectional plan of door fittings are given in the under part of the drawing in fig. 2, same Plate (XXV.) The edge of the door *a*, as looking at it from the inner side, is shown at *p p*, *q q*, being the ends of the tenons of top rail (see fig. 65); *r r*, the hinge; *n n*, front view of architrave; *o o*, the wall, in the void of which the door is hung. In the under drawing to the right, part of front surface of door is shown; *s s*, the architrave; *t t*, the wall.

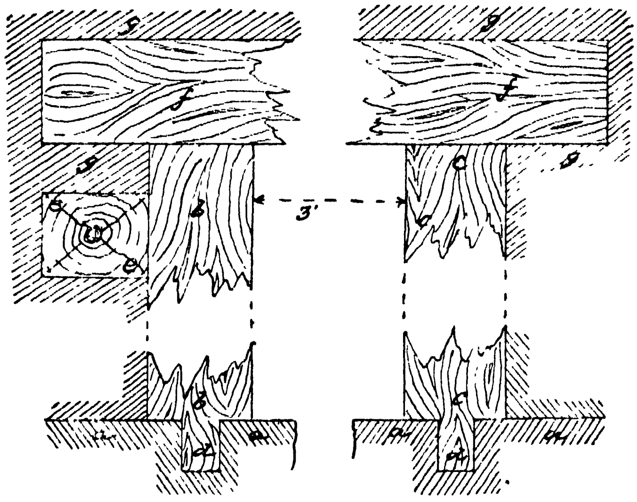


Fig. 66.

Joints of Styles and Rails in Panelled Doors.

In figs. 3 and 4, Plate XXV., we give illustrations of methods of joining rails and styles, or rails and mortises. Let *a b c d*, fig. 3, be the style, with moulding stuck on edge; *f g h* is part of the rail, with tenon *f*, shown by dotted lines in style *a b c d*. Front view of tenon and face of mitre of chamfer at *p*, looking at *a b c d* in the direction of arrow 1, is shown in the lower diagram at *k′*, *p′* and *e″*.

THE STONE MASON AS A TECHNICAL WORKER.

THE PRINCIPLES AND PRACTICE OF, AND THE MATERIALS HE EMPLOYS IN, HIS WORK.

CHAPTER XI.

At the end of last chapter we stated some points connected with "base courses" of buildings, and illustrated one form in connection with fig. 63, *ante*, as the simplest adopted, *d* being the line of wall at the corner of a structure, *e* the base course. In this the wall *d* springs directly from the upper part of base *e*, at some little distance from its end, so as to form a "set-off" or return, as is shown. Some of the baldness of this is taken off by having as the last course of the base-course bricks what is called a "splayed" course (see the paper on "Brickwork"), or if stone be employed the upper course is bevelled or splayed off as shown at *f f*. In more advanced work this splay is converted into or replaced by some simple "moulding," as at *g g*.

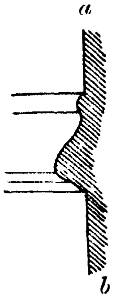


Fig. 65.

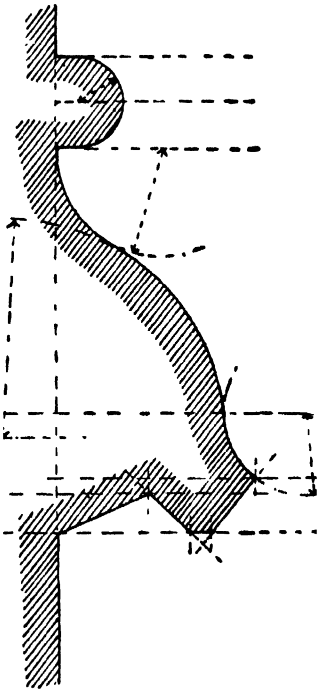


Fig. 66.

Base Mouldings of Buildings.

Fig. 64 illustrates—one-fourth full size—in section to the left and in part elevation to the right, the "base moulding" for a mansion of ten to twelve rooms, such as the reader will find illustrated in the paper called "The Young Architect and Engineer," in figs. 1 to 11. The scale to which fig. 64 is drawn is

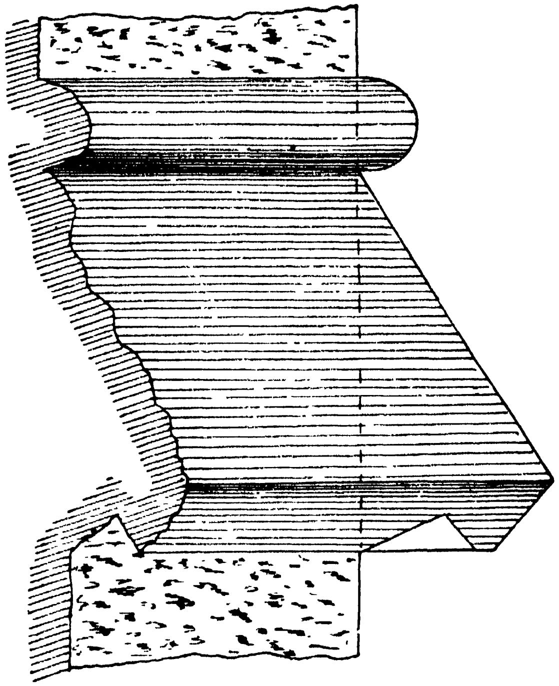


Fig. 67.

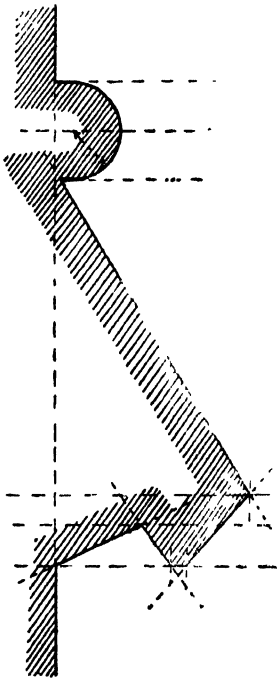


Fig. 68.

3 inches to 1 foot, or one-fourth full size. Fig. 65 is a section of a Gothic base moulding also accepted for a string course: see next paragraph. In fig. 66 we give a section, and in fig. 67 front elevation of a "base moulding" in the more elaborate style of the "Domestic Gothic" (see the paper above referred to), and in fig. 68 the section and in fig. 69 the elevation of another form in the same style. The scale to which figs. 66, 67, 68, and 69 are drawn is six inches to the foot, or half size.

"String Courses" in Buildings.

What are called "string courses" are members introduced to break the line or vertical face of wall, and at the level of the different stories of the edifice. Like the "base mouldings," they run along the whole length of wall. It is only in houses finished in a superior style that these two members run round the whole house. In ordinary buildings they are carried along the front wall only, being retained for but a short distance at the end walls—breaking off there. In some cases the "base moulding" is returned and passed along the end walls, but rarely continued round the back wall. The same holds true of "string courses," although, even in cases where the base moulding is carried round the ends, the "string course" is confined to the front wall, having a short return only at the ends. All depends upon the character of the building, according to the pretensions it makes to be a complete and more or less elaborate design, or to the means of the owner. The simplest of all string courses is a mere course of brickwork, such as *b b*, dividing the lower face of wall, *a a*, from the upper, *c c*, fig. 70; or a further advance may be made by adding to the number of courses, as at *d e*, between lower wall *f* and upper *g*. The single course *b b*, as well as the three courses stepped off as at *d e*, project from the face of wall. It is this projection which is the feature of the "member," and gives character to this part of the elevation, stonework admitting of being moulded and cut or carved at will; string courses of stone are generally finished with moulded faces, or they may be left plain, as at *b b* in fig. 69. A moulded string-course block is shown at *h h* in section and *i i* in elevation. The mouldings in figs. 66 and 67 might be used slightly modified for those of a string course. Fig. 71 illustrates a "string course," *a*, and a "window head," *b*, in one. Scale 1 inch = 1 foot, or one-twelfth of full size.

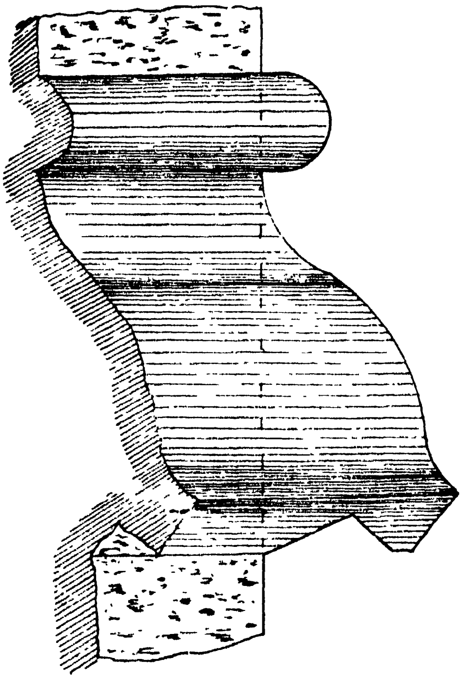


Fig. 69.

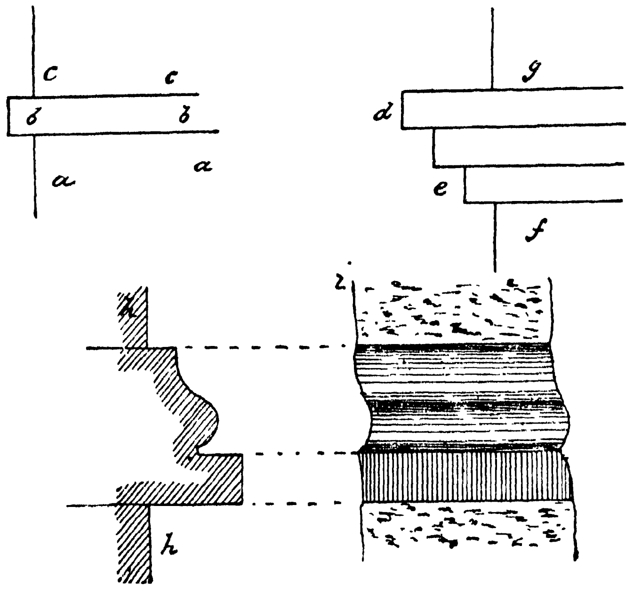


Fig. 70.

Cornices or Cornice Mouldings in Buildings—Cornice Blocks.

Cornice mouldings, as the name implies (see "Cyclopædic Dictionary of Technical and Trade Terms") are those which finish, terminate, or crown the walls, and are placed at their highest point. They add dignity and completeness to, and afford a pleasing object for the eye to look upon at, the upper part of a wall. Some of the happiest efforts of our architects have been displayed in the treatment and finish of the design for the cornices of a building. Where the projection is skilfully managed, they give, in conjunction with that of the windows and the doors, the fine play of light and shade produced by the alternation of projecting and recessed parts which distinguishes a well-designed elevation.

THE BRICKLAYER OR BRICKSETTER.

THE PRINCIPLES AND PRACTICAL DETAILS OF HIS WORK.

CHAPTER VIII.

"Breaking Joint," to secure "Bond," necessitates the Use of Parts of Brick in Courses.—"Closers."—"Closures."

BUT while "bond" gives the security to the wall required, it throws any arrangement aside by which an even number either of "header" bricks or "stretcher" bricks can be used in any one course. Thus, in the arrangements shown in fig. 3—"Old English" bond—the end of the wall, as 5 6, is finished vertically off, by either a "stretcher" or a "header," as the case may be. But by introducing the system of "breaking joint," as in fig. 4, this evenness of finish at the ends of a wall cannot any longer be obtained, and voids or breaks are introduced. This is illustrated in fig. 5: beginning with the first course which we make use of—"stretchers" (Old English bond), *a*, *a*, *a*—the next course, which is one of "headers," must be so arranged that the joint *b* of the two "stretchers" in the first course shall be covered by the solid parts of the "header," as *c* in the second course, the centre of this covering the joint *b*. Carrying on this course of "headers," we find it finishes with a break or void, *d*, caused by one-half of the header at the end projecting, as at *e*, beyond the end of the "stretcher" below it. Taking the next course—another row of "stretchers"—the joint *f* is placed immediately above the centre or solid part of the "header" *c* below it; the joints *g* and *h* of the two "headers" being covered by the solid parts of the two "stretchers" *i* and *j* above. The first course of "headers" is finished by the header *k*, but this is too short—so to say—for its end to come up flush with the end *l* of the "stretcher" *a* below it. Another void or break or empty space is left, therefore, at *m*. But by starting the two courses (first and third) of "stretchers" as shown, the "header" *k* in the second course has to be so placed that it leaves a void, or a break, *m*, at the left-hand side of the wall; thus, at every alternate course these breaks occur alternately to the left-hand and right-hand ends of the walls, as at *m*, *n*, *o*, *p*. These breaks, or voids, must be filled up so as to make a proper solid and vertical finish to the ends of the wall.

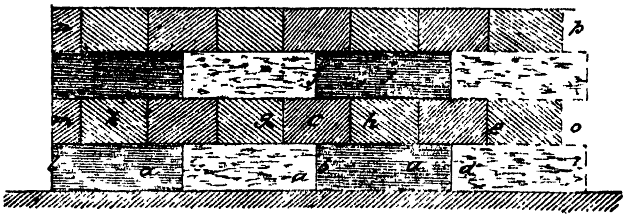


Fig. 5.

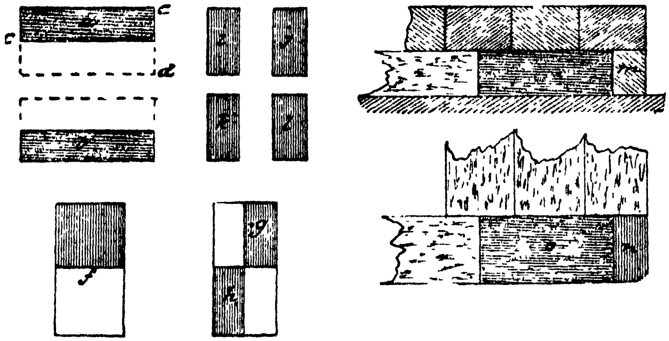


Fig. 6.

Different Kinds of Closer or Closure Bricks.

It will be observed that in all cases the width of these voids or breaks is equal to half the width of a brick on its face, so that to fill them up half-bricks are used. These are known technically as "closers" or "closures," as closing up or finishing the wall; and are obtained or formed by cutting a brick in two in the direction of its length, as at *a* in fig. 10. Thus one brick gives two closers, as *a* and *b*, as shown by the dotted lines. These "closers" are half-bricks, in the sense of being half in the direction of the length, as *c d*, as well as in the direction of the breadth, as *d e*. But in some cases a "closer" is not required the whole length of the brick, but only half of the length; a half-closer is therefore cut in two by the line *f*, thus giving two "quarter-closers," *g* and *h*, or four out of a brick, as at *i*, *j*, *k*, *l*. In the same figure the void, as *o* in fig. 5, is shown filled up with the quarter-closer *m*, as in elevation, and *n* in plan, the "stretcher" *o* corresponding to *d* in fig. 6. It is obvious that by arranging the courses as in fig. 5, so as to throw the voids to the outer extremities of the wall, the arrangement would not be very sightly nor strong. The practice, therefore, is to make the "closer" in a course always, or at least generally, *the last brick but one* in each course. This is shown in fig. 7, in which *a b c d* is the front elevation of the first course of stretchers, the "closer" being placed next the last stretcher, as at *a* at one and *b* at the other extremity of the wall; *c* and *d* are the last stretchers shown in plane at *c'* and *d'*, *a'* and *b'* corresponding to *a* and *b* in elevation. The second course, or that of "headers," the bond being "Old English," is shown in the lower part of fig. 7; *a* is the "closer" in elevation *a'* in plane, and is placed next to the last "header" *b* and *b'*, nearest the end of wall. In the same figure *e* shows a "quarter-brick" closer and *f* a "half-brick" closer, as used in the second course of a brick-and-a-half-thick wall in English bond. In some cases a three-quarter-brick closer is required, as *g*.

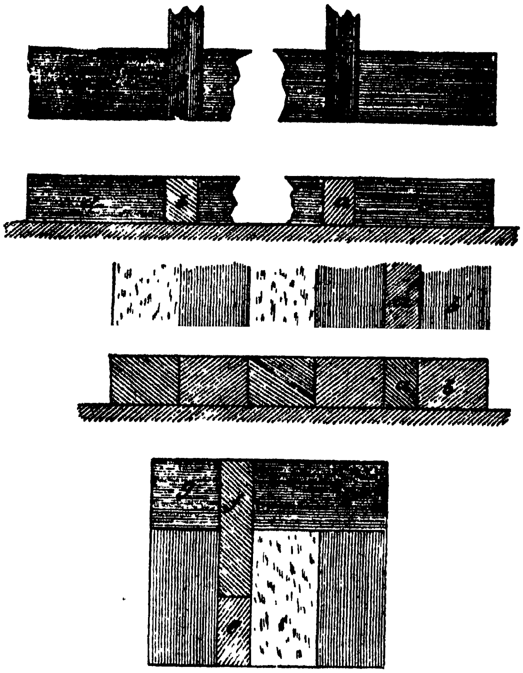


Fig. 7.

"Bats" in Brickwork.—Splayed Bricks.—King Closers.

If a brick be thus cut across in the direction of its breadth at a line *a b*, fig. 12, one-fourth from the end, the other or three-quarter part is usually called in the technical language of brick-setting a "bat"—although this is often used to denote broken bricks, or rather parts of bricks, whatever the proportion that part bears to the whole brick; only that the bricks in this case are cut in the direction of their breadth, as at *a b*, not in the direction of their length, as *e d*. What is known and called a "king closer," is a brick cut, or which should be cut, of the form shown at *d e* in fig. 8, the crossed part *f f* being cut out, forming a shoulder at *g*; this is shown in side elevation at *d" g" e"*. But as in practice this cutting is not easily executed so as to be accurate, or without running the risk of breaking the brick, the usual practice is to cut the brick as at *h*, cutting off the crossed part *i*. This forms what is called also a "splayed brick," as at *j*, the angular part *k* being the "splay" or bevel, and from this a "splayed" is sometimes called a "bevelled brick."

"Reveals"—"Jambs" in Brickwork.

The form of closer now illustrated, "king closer," as it is used at the corner of the opening or "void," as it is termed, of a window or door at that part known as the "reveal" and "jamb" (in Scottish building construction technically called a "rybat," clearly a mere corruption of the term "rebate": see "Mason" and "Carpenter" and the "Cyclopædic Dictionary" for the meaning of the term). A window or door opening may have its sides or interior parts, as *a b*, *c d*, at right angles to the wall *e f*, fig. 9, the parts *a b*, *c d*, having no projections. This part *a b* or *c d* is called the "jamb," and sometimes the "cheek" of a door or window opening. When there is a projecting part to this, as at *i j j* in fig. 9, the name "jamb" is applied only to the inner part, as *g h*, the part *i j j* being called the "reveal."

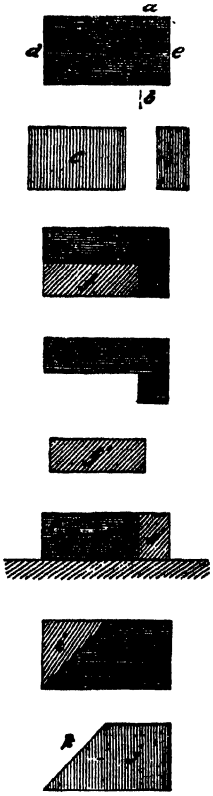


Fig. 8.

THE GRAZIER AND CATTLE BREEDER AND FEEDER.

THE TECHNICAL POINTS CONNECTED WITH THE VARIETIES OR BREEDS OF CATTLE—THEIR BREEDING, REARING, FEEDING, AND GENERAL MANAGEMENT FOR THE PRODUCTION OF BUTCHERS' MEAT AND OF DAIRY PRODUCE.

CHAPTER XVI.

At the end of last chapter we pointed out certain assumptions which had been made with regard to the action of certain constituents in food on the animals partaking of it, which assumption tended to the holding of erroneous views as to the values of food. These assumptions set aside the what may be called common-sense considerations we named. Amongst other points overlooked is the element of life, to which we have already referred. This, while one of the most mysterious with which man has to deal, is one also of the most potent, as in its manifestation the most diversified. As in man, so in animals, they have their own individual peculiarities, their likes and dislikes; so that what suits one will be totally unsuitable for another. It is in this direction, also, that the characteristics of what we call the breed of animals influence the value of the food they are fed upon. It is well known, for example, that there are some breeds which fatten much more quickly than others. All these considerations, and others which will come up in their place, point to the difficulties attendant upon defining with precision what the results of using certain foods will be. But while chemistry cannot do all, it can do, and has done, much to give a very remarkable, and certainly a highly useful character of precision—formerly altogether unknown—to the work of the cattle feeder.

All plants are divided by the chemist, so far as they are considered as feeding substances, into two great divisions—the "non-nutritive" and the "nutritive." The "non-nutritive" constituents are water, ash, and woody fibre. The "nutritive" are classed under three heads. First, the nitrogenous or albuminous compounds, or what are sometimes termed the protein elements of food. These go to form flesh, and are thus also sometimes styled the flesh-forming constituents of food. The second class are the non-nitrogenous compounds, or those which are fat-producing. They also go to sustain the heat of the animal, and are therefore sometimes called the carbonaceous or heat-producing elements. They are composed of the starch, sugar, and what is called extractive matter. The third class of the non-nitrogenous compounds are the oil and fatty matters, which also go to the formation of heat. Such is the division formulated by the chemist; and although it is chiefly made for the convenience of analysis, and is not held by all chemists as strictly correct, still, as a rule, the division into nutritive and non-nutritive constituents is what may be called the expression of the chemical view of the subject. We shall see presently that physiologists take exception to the classification. All foods used by the farmer in feeding his stock may be divided into seven classes. First, the cereals or corns, as wheat, etc., etc.; second, the leguminous crops or plants, as beans, pease, lentils. Then come the root crops, as turnips, potatoes, etc., etc. The fourth class is made up of the straws and refuse of the cereal crops; while the fifth comprises the grasses, meadow hay, and clover. The sixth is made up of the leaf crops, such as the cabbage, and the leaves of turnips. And last come the oil cakes and various feeding cakes and "cattle foods," forming the seventh and not the least important.

Taking this, the chemical classification of farm foods and their constituents, we now give a list of their analyses, showing their composition.

Percentage of Non-Nutritive Constituents of Feeding Substances in 100 Parts.

THE CEREAL CROPS.

Names of Feeding Stuffs.	Water.	Woody Fibre.	Ash.
Wheat	14·0	1·7	1·6
Barley	14·0	13·2	4·2
Oats	13.6	12·6	3·0
Rye	13·0	10·29	1·7
Maize or Indian Corn	14·0	5·0	1·0
LEGUMINOUS SEEDS, AS BEANS, ETC.			
Beans	14·8	9·2	3·5
Pease	14·1	10·0	2·5
Lentils	14·0	12·5	1·5
Lupines	14·5	11·5	3·5
STRAWS OF THE CEREALS AND LEGUMINOUS SEEDS.			
Wheat	14·23	45·45	7·47
Barley	14·30	39·80	4·24
Oats	12·06	43·60	4·85
Rye	14·30	43·18	3·08
Beans	20·90	......	6·35
Pease	12·00	47·52	6·00
REFUSE OF THE CEREALS, ETC.			
Bran	12·86	11·50	6·11
Malt-Coombs or Cummins	6·24	......	8·70
Oat Dust	9·31	......	7·70
Barley Dust	11·03	......	7·31
Rice Dust	12·02	36·67	13·49
ROOT CROPS—TURNIPS, ETC.			
Swedes	89·40	2·54	0·623
White Globe Turnip	90·43	1·02	1·02
Mangold Wurtzel	87·78	1·12	0·96
Carrots	85·0	1·7	1·0
Parsnips	88·3	1·1	0·7
Kohl Rabi	87·0	1·1	1·0
Jerusalem Artichokes	80·0	1·3	1·1
Potatoes	75·0	1·3	0·9
Beet-Root (Sugar)	81·5	1·3	0·8

GRASSES AND CLOVER CROPS.

Names of Feeding Stuffs.	Water.	Woody Fibre.	Ash.
Rye Grass	71·43	10·06	2·15
Italian Rye Grass	75·61	4·82	2·21
Lucerne	73·41	......	3·08
Sainfoin	77·32	......	1·73
Vetch	82·16	......	1·54
Red Clover	80·64	......	1·97
White Clover	83·65	......	1·57
Yellow Clover	77·57	......	2·00
Alsike Clover	76·67	......	2·06
Green Rape	87·05	3·56	1·60
Sorghum	81·80	4·05	0·23
HAY CROPS.			
Meadow Hay	16·94	27·16	5·04
Aftermath	13·06	19·02	7·46
Clover Hay	16·84	......	5·51
CABBAGES AND OTHER LEAF CROPS.			
Cabbage	89·00	2·0	1·2
„ Stems	82·0	2·8	1·9
Turnip Tops (Swedes)	88·36	......	2·29
„ „ (Yellow)	91·28	......	1·52
Mangold Leaves	91·96	1·3	1·29
Artichoke Stems	80·0	3·4	2·7
Carrot Leaves	82·2	3·0	3·6
OIL-CAKE AND MISCELLANEOUS SUBSTANCES.			
Linseed Oil-Cake (Best)	12·36	15·94	5·41
„ „ (Average)	12·70	......	5·89
Rape Cake	10·68	......	7·79
Cotton Seed-Cake	11·34	21·24	6·54
Locust Beans	14·22	3·88	0·62
"Royal Patent Cake"	10·18	13·24	4·32
"Royal Spiced Cake"	15·42	16·74	5·04
"Feeding Meal" (Residue from Indian Corn Starch Manufacture)	8·32	24·69	1·02
Palm Nut-Meal	10·70	15·18	3·49
Cracklings or Greaves Meal	11·80	......	6·44

Percentage of Nutritive Constituents of Feeding Substances in 100 Parts.

THE CEREAL CROPS.

Names of Feeding Stuffs.	Albuminous Compounds.	Non-Nitrogenous Compounds.	Oil and Fatty Matter.
Wheat	14·6	66·1	1·2
Barley	12·8	55·5	0·3
Oats	17·0	48·1	5·7
Rye	13·83	60·26	0·95
Maize or Indian Corn	12·00	60·3	7·7
LEGUMINOUS SEEDS, AS BEANS, ETC.			
Beans	24·00	46·5	2·0
Pease	23·40	58·0	2·0
Lentils	26·00	44·0	2·0
Lupines	34·5	28·0	6·5
STRAWS OF THE CEREAL CROPS AND LEGUMINOUS SEEDS.			
Wheat	1·79	31·06	......
Barley	1·68	39·98	......
Oats	1·63	37·86	......
Rye	2·29	37·15	......
Beans	6·79	65·96	......
Pease	12·55	21·93	......
REFUSE OF THE CEREALS, ETC.			
Bran	13·80	50·17	5·56
Malt-Coombs or Cummins	25·62	59·44	......
Oat Dust	6·92	72·86	3·21
Barley Dust	8·46	69·73	3·47
Rice Dust	6·69	25·52	5·61

ROOT CROPS—TURNIPS, ETC

Names of Feeding Stuffs.	Albuminous Compounds.	Non-Nitrogenous Compounds.	Oil and Fatty Matter.
Swedes	1·44	5·93	......
White Globe Turnip	1·14	2·96	......
Mangold Wurtzel	1·54	8·60	......
Carrots	1·5	7·4	0·2
Parsnips	1·6	7·24	0·2
Kohl Rabi	1·6	7·3	0·1
Jerusalem Artichokes	2·0	13·8	0·5
Potatoes	2·0	19·6	0·3
Beet-Root (Sugar)	1·0	14·0	0·1
GRASS AND CLOVER CROPS.			
Rye Grass	3·37	12·08	0·91
Italian Rye Grass	2·45	14·11	......
Lucerne	4·40	19·11	......
Sainfoin	2·51	17·43	......
Vetch	3·56	12·74	......
Red Clover	3·60	13·78	......
White Clover	4·52	10·26	......
Yellow Clover	4·48	15·94	......
Alsike Clover	4·82	16·44	......
Green Rape	3·13	4·00	0·61
Sorghum	1·53	9·84	2·55
HAY CROPS.			
Meadow Hay	10·69	40·17	0·4
Aftermath	10·75	49·74	......
Clover Hay	13·52	64·43	......
CABBAGE AND OTHER LEAF CROPS.			
Cabbage	1·5	6·3	0·4
„ Stems	1·1	12·2	0·3
Turnip Tops (Swedes)	2·08	7·25	......
„ „ (Yellow)	2·45	4·74	......
Mangold Leaves	1·76	4·98	......
Artichoke Stems	3·3	10·6	0·8
Carrot Leaves	3·2	8·0	1·0
OIL-CAKE AND MISCELLANEOUS SUBSTANCES.			
Linseed Oil-Cake (Best)	29·69	21·64	14·96
„ „ (Average)	28·21	29·42	11·32
Rape Cake	29·53	30·98	11·10
Cotton Seed-Cake	23·72	30·98	6·18
Locust Beans	7·22	71·48	0·96
"Royal Patent Cake"	20·06	48·91	3·29
"Royal Spiced Cake"	15·12	44·24	3·44
"Feeding Meal" (Residue from Indian Corn Starch Manufacture)	19·31	38·22	8·64
Palm Nut-Meal	18·01	41·51	11·11
Cracklings or Greaves Meal	24·75	36·93	20·80

In estimating the value of a food for fattening cattle, the attention of the chemist is given only to the nitrogenised or albuminous compounds, and the non-nitrogenous or carbonaceous, as the mineral substances, phosphates, alkaline salts, such as of sodium and of iron, and which go to form the bones of the animal, are found abundantly in all plants. The division we have just given would seem as if there were three classes of "nutritive" elements—namely, the nitrogenous and the non-nitrogenous, and, third, the oils and fatty matters. But in reality the oils and fatty matters are part of the non-nitrogenous elements—the starch, gum, sugar, and extractive matter, going to promote heat and to aid breathing—hence they are called often the "respiratory compounds" of food—the oil and fatty matter going to promote fat.

THE STEEL MAKER.

THE DETAILS OF HIS WORK—THE PRINCIPLES OF ITS PROCESSES—THE QUALITIES AND CHARACTERISTICS OF ITS PRODUCTS.

CHAPTER VI.

WE have said in preceding chapter that there have been various attempts made to produce steel direct from the ore; this system obviously saving much time and labour, as compared with that, for a long time the only one practised in modern times, in which several processes had to be gone through before the final or ultimate product of steel was produced from the primary or original ore. The reader will perceive, from what has been already given on this head, that the direct process of reduction of steel from the ore possesses a certain charm or fascination for the practical man; inasmuch as it proposes to do for him at once what is only done for him on the ordinary system by several processes, and those so related to each other that this has been sometimes called the roundabout system. Nor does the direct process possess a less fascination for the man of science; for it carries with it the possibility that by acting directly and immediately upon the ore, the source of the metal, not only time will be saved, but that deteriorating constituents will be kept out of the ultimate product, which will thus practically be all the more valuable for constructive purposes and the varied arts of life. For it is, at least in this connection, argued as a conceivable thing, that if steel is made on the roundabout system—that is, in which several processes are gone through, each one following the other—in each process there is a likelihood of deteriorating constituents getting access, so to say, to the product, reducing in proportion its practical value. And this is all the more likely to be the case, seeing that the ore is brought in contact with so many materials differing more or less, and in some cases wholly, from the ore which yields the metal desired. That this untoward result is in one instance brought about, is well known, it being but too notorious that one process in the roundabout system yields a metal of a debased kind, and that in degree worse than many are disposed to admit. What this part of the roundabout style of making steel is, we refrain from further referring to, to prevent that confusion of ideas which a fuller explanation of it would be liable to create in the minds of our readers.

Of the various attempts made to produce steel direct from the ore, nearly all of those recently introduced have necessitated appliances more or less complicated, but all specially constructed and arranged for the system. We have said that those methods, however successful in the mere production of steel, have been so surrounded with difficulties in carrying out the details of practice, that they have been all commercial failures. We now approach one which, taking the well known appliance used in the ordinary iron and steel making just as it is in principle, has aimed at making it do in a simple what other inventors have tried to do in a much more complicated and expensive way. The appliance here alluded to is the well known and long used one known as the reverberatory heating or reducing furnace, of which the principal feature is called the "open hearth"; in which the heating or reducing process is carried on.

In connection with the modern method of "open-hearth" steel making, the name of the late Sir William C. W. Siemens will be for all time most honourably known. This distinguished scientist and Sir Henry Bessemer, while, as we shall see, each working in a totally different direction, have revolutionised the iron, or perhaps we should say the steel trade—although the new steels include within their various classes wrought iron of a superior quality, or a very mild steel. Sir William Siemens was also distinguished as a practical man, and in addition to his scientific attainments of the highest order, was in the first rank of our engineers. One form of furnace, the "regenerative gas furnace," and with which his name is so intimately connected, has introduced quite a new era in what may be called the art of "high heating"; and we believe it to be that which will completely revolutionise furnaces, and be the means of effecting that economy in the combustion of fuel which it has been and is now the aim of many to realise, and which has engaged the attention of a host of inventors.

This "regenerative gas furnace" is indissolubly connected with the "open-hearth" process of making steel, and it is the agency, indeed, by which the success of the method can only, we think, be secured; and that from the high temperatures which the method necessitates, and which the regenerative gas furnace alone of all the modern furnace contrivances can give. More than one inventor had brought out systems for making steel on the "open-hearth" process, long before Dr. Siemens entered the field. Amongst these was Mr. John Heath, who discovered a method of applying the well known substance manganese to the making of steel, and which opened up quite a new era in the old, or what we call the ordinary method of steel making, which will be described in a succeeding paragraph. Mr. Heath was distinguished by his ability, and as much so, unfortunately for him, by the energy he displayed in meeting the attempts of the steel manufacturers to evade his patents, which they did with so much success as to send him broken-hearted to his grave—not the first of those connected with the iron trade to meet with such an end. Mr. Heath failed in his application of the open-hearth process to the making of steel solely—at all events chiefly—through his inability with the means at his command to obtain the very high temperatures which were necessary for the success of the method. Curiously enough, Mr. Heath seemed in one direction to have anticipated the method of using gas as a heating medium, carried out in an infinitely more direct and successful way in the Siemens regenerative furnace. High as are the temperatures created by this furnace—temperatures far exceeding any which even the most sanguine of metallurgists conceived to be possible of attainment—there is but little doubt, we think, that much of the future success of steel making depends upon the makers having a still higher—possibly a very much higher—heat than the best form of regenerative furnace can now give. To the production of those exceedingly high temperatures some of our ablest scientific men are now directing their attention. If steel making direct from the ore by a modification of the open-hearth principle ever be a complete success—that is, if it can be carried on so that it can "pay," or rather yield, what all inventors aim at, a large profit—we believe it will be when these higher temperatures than can now be got are at the command of the steel maker. From this the reader will perceive that, although Dr. Siemens had by his open-hearth process gone far to solve the problem how to produce steel direct from the ore on a commercially paying scale, the solution has not as yet been attained. The problem of commercially successful steel working direct from the ore has yet to be solved. In a future chapter the reader will learn that in making steel from manufactured iron—as in the Bessemer process—or from a combination of manufactured iron and natural ore, Dr. Siemens was, however, eminently successful, commercially as well as scientifically. The following is a brief description of the Siemens direct process of steel making. The open-hearth process, so successfully carried out by him in making steel from manufactured iron, is so far modified.

The chief feature of the improved appliances is the employment of a rotatory vessel or drum in a horizontal in place of a vertical position. The advantages of this position are very great. The furnace or rotatory converter is lined with two layers of different substances; the inner, or that next the iron of which the rotator is made, being lined with banxite bricks highly aluminous, and therefore very refractory. This refractory brick lining, which carries the inner lining or that towards the interior of the rotator, is made of a certain thickness of iron oxide produced by melting "hammer scales"—scales the product of hammering processes—together with rich ores. This mixture is placed in the interior of the rotatory furnace itself, while highly heated; and melted, it sets during the rotation of the vessel, and thus the inner lining is completed.

The gases used to heat the furnace are taken direct from the "gas producer," "regenerators" being alone used to heat the air which is mixed with the "gas" in the interior of the rotating drum itself, and there flashed into flame, producing intense heat. The heated air from one of the air regenerators is led to the interior of the rotator, and the gas, flaring through a special channel connected with the "gas producer," is also led there in a continuous stream. From the rotator, where the flame is thus produced, it rushes forward to the heating chamber, and after heating it, passes back again towards the inlet side, and from this passes down through the second air regenerator, to the brick channels of which it gives up the greatest proportion of its heat, which is afterwards given out to the air which is passed through it; when the air-reversing valve being changed in position, this second becomes the first or hot-air-supplying regenerator, the first becoming the regenerator through which the heated products pass from the heating chamber to the chimney.

By this arrangement the front or end opening of the rotating vessel or drum is left free, so that access can be obtained to it for carrying out the process, and is fitted with a charging and discharging door placed eccentrically. The discharging door admits of the easy withdrawal of blooms or balls of iron, and at a level with the lining, when the rotating furnace or drum is stopped at a point of its revolution where the discharging door is at its lowest point.

The process of reduction is similar to that we have already noticed. The charge consists of a mixture of the ore to be reduced, and of fluxing and reducing materials in proportion to the constituents of the ore, to the weight of some 30 or 40 cwt. This is charged into the rotating furnace or drum during the period when its motion has been stopped and the charging door is at its highest point. The drum is then set in motion at the very slow speed of six to eight revolutions per hour, and the gas and air admitted into its interior, flashing into flame, heat the charge uniformly, each part being brought by the revolution of the drum into contact with the heating flames. So soon as the materials are raised to a red heat chemical action commences, the reaction between the ore and the carbonaceous matter of the fluxing and reducing materials causing carbonic oxide gas to be formed. This, as we have already shown, is a highly combustible gas, so that when it meets the heated air from the air regenerator it is flashed into flame and thus adds greatly to the heat in the furnace. When this point is fully reached the supply of gas from the gas producer is cut almost wholly off.

THE CALICO PRINTER.

The Chemistry and Technical Operations of his Trade.

CHAPTER XIV.

Salts of Alkalies (*continued*).

Permanganate of Potash ($K_2Mn_2O_7$) is used in discharging aniline black colour from the "greys" used in printing that colour. It is a powerful oxidising agent and antiseptic. Its red-purple crystals readily dissolve in water.

Chloride of Ammonia, or Sal-ammoniac (NH_4Cl).—This salt is used in catechu colours, and in one or two special colours that are not in general use. It is a readily soluble, crystallisable white salt, which volatilises completely on the application of heat. One part dissolves in ten of water at 13·3° C., the temperature being thereby reduced to —5·1; whilst 77·2 parts are dissolved in 1 part water at 100° C.

SALTS OF MAGNESIUM.

Sulphate of Magnesium—Epsom Salts ($Mg\ SO_4$) is used chiefly in finishing, especially for Turkey red dyed cloth; it is a crystalline, very readily soluble salt.

Chloride of Magnesium ($MgCl_2$) is likewise used in finishing, but has a great disadvantage in that it is liable to decompose into magnesia and free hydrochloric acid by the heat of the drying cylinders. It is a hygroscopic salt.

COMPOUNDS OF CALCIUM.

Lime (CaO); *Slacked Lime*, $Ca(OH)_2$.—The latter of these is used in bleaching and in the lime and copperas indigo vat; it is also used to run cloth printed with some discharge colours through in order to neutralise any acid left in the cloth. Lime (CaO) when treated with water evolves heat, and is converted into the hydrate or slacked lime.

Acetate of Lime, $Ca(C_2H_3O_2)_2$, is used as a mordant, chiefly along with a salt of alumina in printing extract alizarine colours. It is sold both in solution at about 20° Tw., and solid, each form containing impurities of organic matters, tar, etc.

Hypochlorite of Lime, Chloride of Lime, or Bleaching Powder, $CaCl_2 + Ca(ClO)_2$.—The most important use of this compound is in bleaching. It is also employed in Turkey red discharging, and in "chemicking" printed goods—*i.e.*, passing them rapidly through a very dilute solution of the powder, pressing between two rollers and then passing over cylinders heated by steam. This process has the effect of rendering the goods cleaner in appearance. It is sold both in powder and in solution as "chemic" at from 6° to 18° T.; the solutions are free from insoluble matter present in the powder. The powder when good contains 36 per cent. of *available* chlorine, but may contain much less than this. It is highly hygroscopic, contains much free alkali, and is soluble in ten parts of cold water; the solution on boiling decomposes; addition of an acid sets chlorine free, this latter property being the principle of its application in bleaching and Turkey red discharging.

Dilute solution of bleaching powder has no action on most fixed colours, nor on cotton.

SALTS OF ALUMINA.

Alum, $K_2SO_4Al_2 \cdot (SO_4)_3 + 24\,H_2O$.—This important salt is largely used in the branch of industry under consideration. It is employed as a mordant for berry, bark, weld and other yellows and other colouring matters, and as the source of alumina in making acetate and nitrate of alumina. It occurs in commerce generally in a pure or nearly pure state in the form of large well-defined colourless and transparent crystals, soluble in 18 parts of cold and ¼th part of boiling water. Its solution is of acid reaction, and it dissolves metals with liberation of hydrogen gas.

Alum for making red liquor for alizarine reds must be free of iron; this is tested for by acidifying the solution with hydrochloric acid and adding a few drops of solution of ferrocyanide of potassium: an *immediate* blue colour indicates the presence of iron. Sulphate of alumina, or patent alum—$Al_2(SO_4)_3 + 18\,H_2O$—is used for the same purposes as alum, and will in time probably supersede that salt for many purposes. On account of its containing no alkali sulphate, it requires less of sugar of lead to produce from it the same amount of acetate of alumina that alum does. Hence, in the preparation of red liquor it is more economical than alum. It is more liable, however, to contain impurities than the more readily crystallisable salt, alum. Sulphate of alumina is a crystalline salt soluble in two parts of cold water. It contains 15·4 per cent. of alumina and 36 per cent. of sulphuric acid and 48·5 per cent. of water. It behaves with ammonia and soda like common alum.

Alum consists of 36·21 per cent. of sulphate of alumina, 18·31 per cent. of sulphate of potash, and 45·48 per cent. of water of crystallisation. This is equivalent to 10·94 per cent. alumina, 9·89 per cent. potash, 33·68 per cent. sulphuric acid, and 45·49 per cent. of water. There is, however, another kind of alum, containing ammonia in place of potash, the formula of which is $(NH_4)_2SO_4 \cdot Al_2\,(SO_4)_3 + 24H_2O$.

On adding a little ammonia or caustic soda to a solution of alum a white precipitate forms; this is the insoluble hydrate of alumina, $Al_2\,(HO)_6$. On continuing to add more alkali the precipitate dissolves, being converted into the soluble aluminate of soda.

Most other soluble salts of alumina behave in a similar manner when treated with alkali.

Acetate of Alumina, $Al_2\,(C_2H_3O_2)_3$, and *Red liquor*.—The latter fluid is a variable mixture of the former compound with basic sulphate of alumina, sulphate of potash or of ammonia, and sometimes also free acetic acid. It is the most important mordant used by the calico printer; methods for its preparation will be found in another chapter. Both of these substances are always met with in the liquid state, since pure solid acetate of alumina can only be obtained by careful manipulation, and then it quickly decomposes in contact with air. On heating acetate of alumina it readily parts with its acetic acid, leaving a residue of alumina. This is the principle of its application as a mordant. It may be prepared by dissolving hydrate of alumina in acetic acid, the action being represented by the equation

$$2Al_2(HO)_6 + 6C_2H_4O_2 = 2Al_2(C_2H_3O_2)_6 + 9H_2O.$$

It may also be prepared by decomposing acetate of lead with alum or sulphate of alumina; thus,

$$Al_2(SO_4)_3 + 3Pb(C_2H_3O_2) = 3PbSO_4 + Al_2(C_2H_3O_2)_3.$$

Nitrate of Alumina, $Al_2\ (NO_3)$, is used as a mordant, like the acetate. It readily splits up into alumina and nitric acid, which latter, being a powerful oxidiser, generally acts upon the colour; thus, in the case of blocking on the top of orange-yellow, converting it into yellow. On account of this fact it requires care in using. It is prepared by precipitating nitrate of lead with alum.

Muriate or Chloride of Alumina (Al_2Cl_6), is occasionally used as a mordant. Like the last-named salt it readily parts with its acid on heating.

Hydrate of Alumina, $Al_2\ (HO)_6$, is used in making mordants, by dissolving it in the requisite acid. It is prepared by precipitating a salt of alumina with alkali, taking care not to use excess of the latter.

Aluminate of Soda, or Pink liquor ($Na_2Al_2O_4$), is used for mordanting pinks, and acts as a first-class mordant. It is sold by the manufacturers both in the liquid and solid state.

China clay is largely used in stiffening and weighting prints. It is found native in Cornwall and other places. It is a heavy white powder, a silicate of alumina; for finishing purposes it is important that it should be very white and quite free from acid, alkali, or other injurious soluble matters.

SALTS OF IRON.

Green Copperas, or Ferrous sulphate ($Fe\ SO_4 + 7H_2O$).—This salt is employed as a mordant and in making acetates of iron; also in the indigo vat. The pure salt occurs as transparent pale green crystals soluble in water; on exposure to the air, or on adding nitric acid or bichrome or permanganate of potash, it becomes oxidised or converted into per-salt of iron or ferric salt, the additional amount of oxygen thus absorbed giving the salt new properties. Thus, whilst in the ferrous state it gives a white precipitate with ammonia and with ferrocyanide of potassium, and no action with sulphocyanide of potassium, it now gives a bright rust-red precipitate with the first-named, deep Prussian blue with the ferrocyanide, and a deep blood-red colour with sulphocyanide. These tests distinguish the two salts from one another and from all other substances. Commercial green copperas is frequently contaminated with ferric sulphate and oxide.

Muriate of Iron is seldom employed as a mordant.

Nitrate of Iron, or Black Iron liquors.—These are largely used for logwood blacks; also for discharge black on Turkey red. They are of various composition, being sometimes ferric nitrate, and sometimes mixtures of ferrous and ferric nitrate and ferrous and ferric chloride. They are sold at strengths varying from 38° to 120° T. They are also prepared by dissolving iron in nitric acid; also from a mixture of nitric acid, scrap iron, and copperas. The amount of iron they contain is exceedingly variable, the only criterion of value being chemical analysis.

Acetate of Iron, Ferrous Acetate, or Iron liquor, $Fe(C_2H_3O_2)$, is used as a mordant for alizarine lilacs, chocolates, and blacks; for logwood, bark, gall, and tannin blacks. It occurs in commerce as an olive-green or black liquor at 7° T.; it is prepared by dissolving old iron in crude acetic acid or wood vinegar. It is also produced by decomposing acetate of lead or of lime with alum. On exposure to the air it oxidises, like copperas, and gives the same reactions as that salt with ammonia, ferrocyanide, and sulphocyanate of potash.

Acetate of Iron, Ferric Acetate, or Iron liquor, $Fe_2(C_2H_3O_2)_3$. This compound, used as a mordant in calico printing, though not to any great extent, is in request for dyeing. It is produced by adding a slight excess of ferric sulphate, $Fe_2(SO_4)_3$, to acetate of lead or lime; on standing lead or calcium sulphate, and a little basic ferric sulphate precipitate, leaving ferric acetate in solution. It is also produced by dissolving ferric hydrate, carbonate or oxide in strong acetic acid.

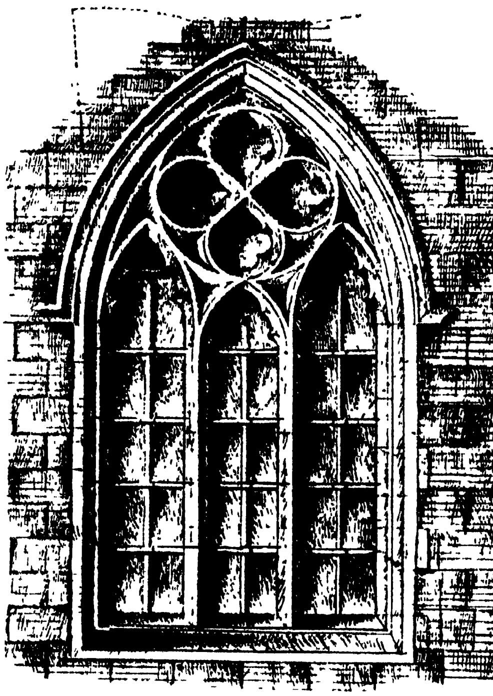
Most of the acetate of iron liquors in use are mixtures of the two preceding compounds.

SALTS OF CHROMIUM.

Chrome Alum, $Cr_2\ (SO_4)_3,\ K_2\ SO_4 + 24\ H_2O$.—So called from its constitution, which, it will be observed from the formula, corresponds to alum. Its use in calico printing is in the preparation of acetate of chrome, and in one or two colours, such as catechu brown. The commercial article, like alum, occurs in large well-defined crystals of the pure salt: these are of a fine green colour, soluble in water. The solution of any soluble chromium salt gives a green precipitate of $Cr_2\ (HO)_6$ with ammonia.

THE STONE MASON.

Gothic Windows. Figs. 1, 2, Style Geometric; Figs. 3, 4, Curvilinear Decorated.



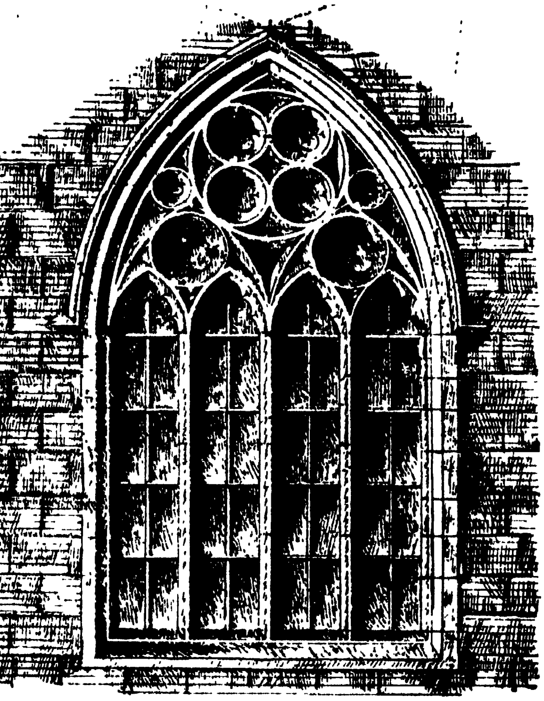


Fig. 2.

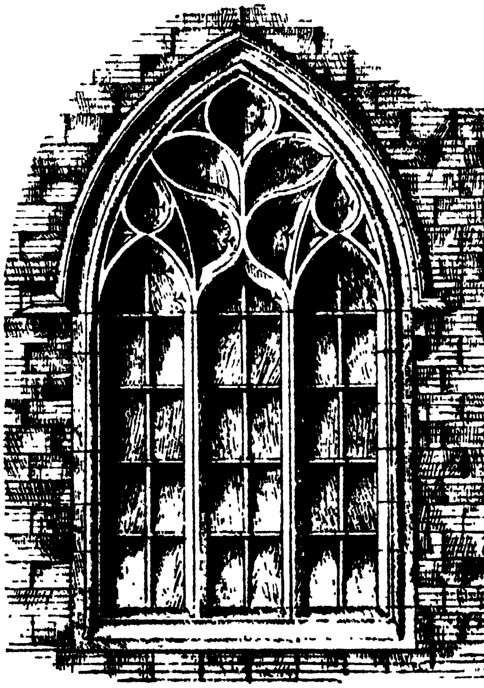


Fig. 3.

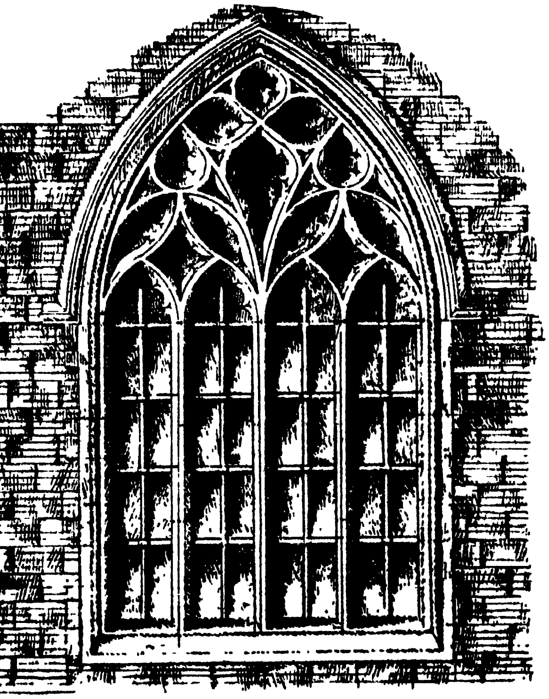


Fig. 4.

PARTITIONS.

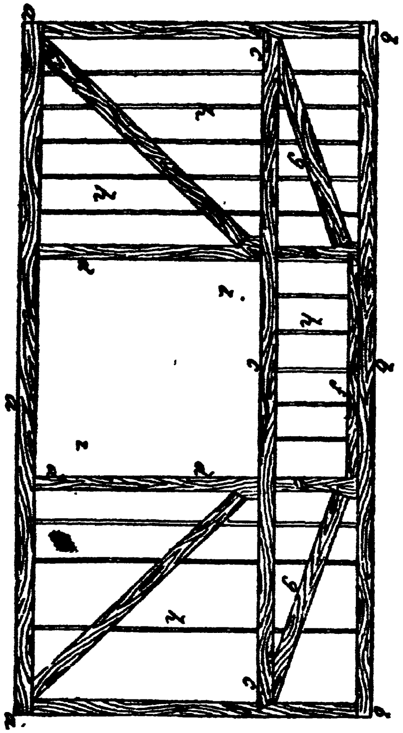


FIG. 1.

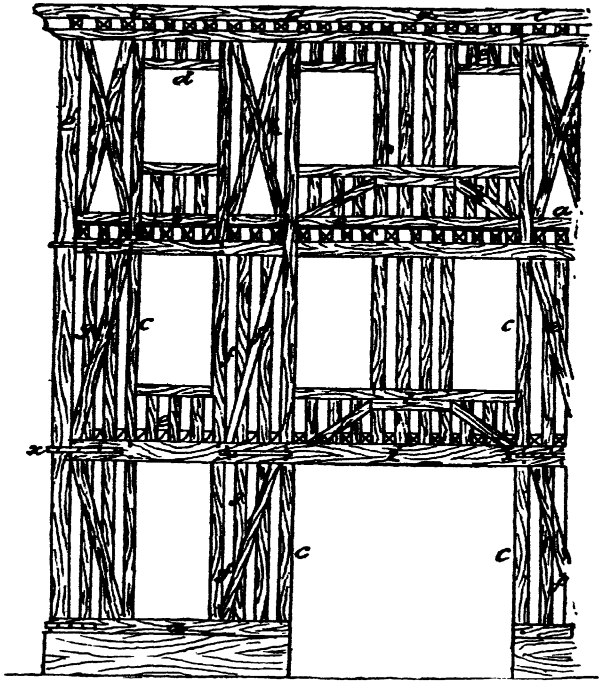


FIG. 2.

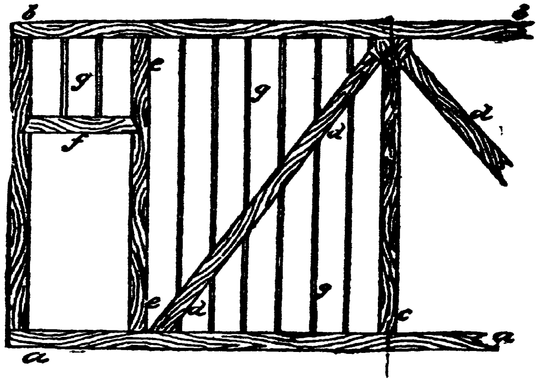


FIG. 3.

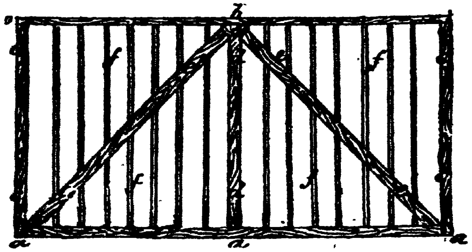


FIG. 4.

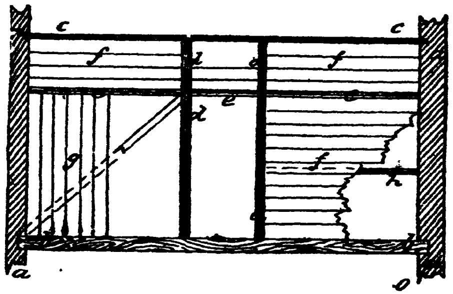


FIG. 5.

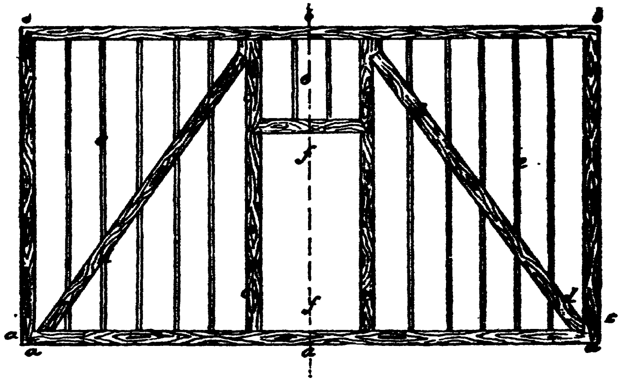


FIG. 6.

[Plate CLXXVIII.

FIG. 1, ELEVATION OF SEMI-DETACHED VILLAS; FIG. 2, GROUND PLAN; FIG. 3, CHAMBER PLAN; FIG. 4, CELLAR PLAN.

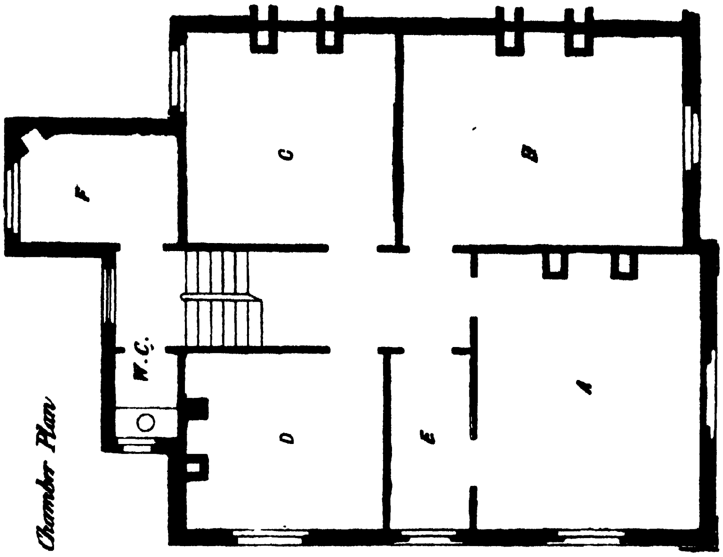


FIG. 3.

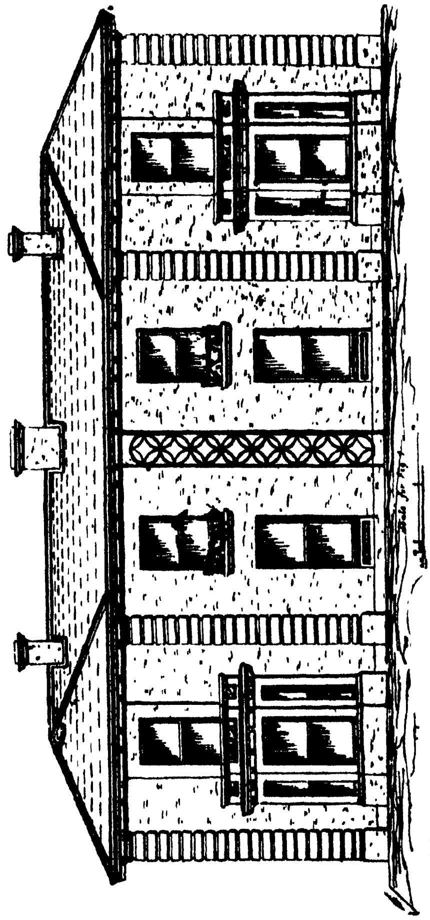
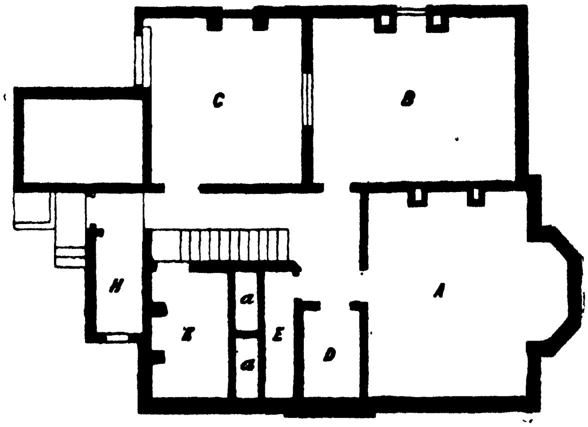
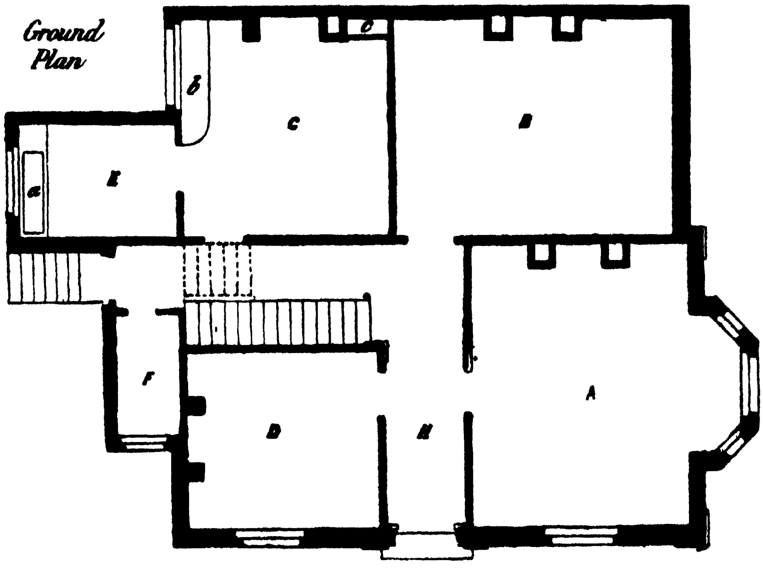
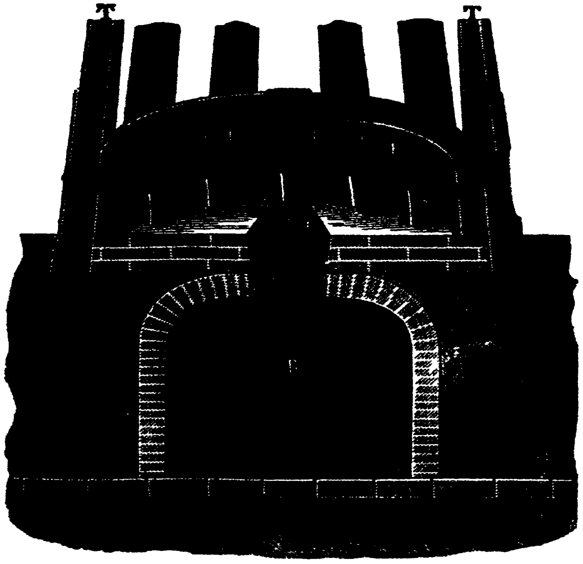


FIG. 1.



Cellar Plan
FIG. 4.





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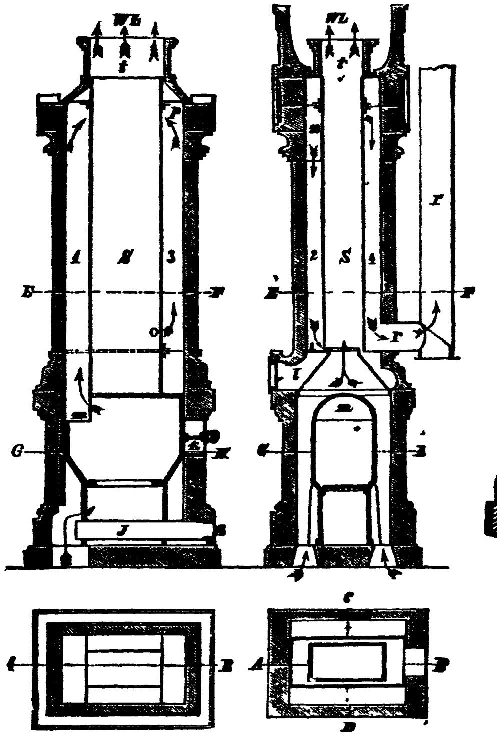

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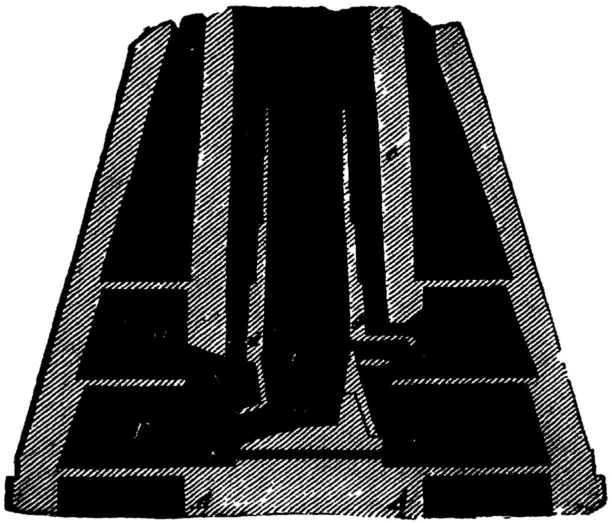

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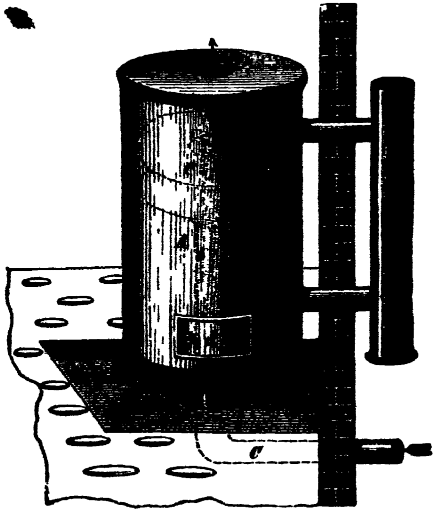

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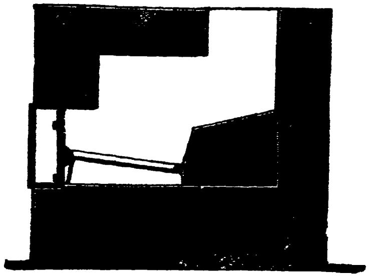

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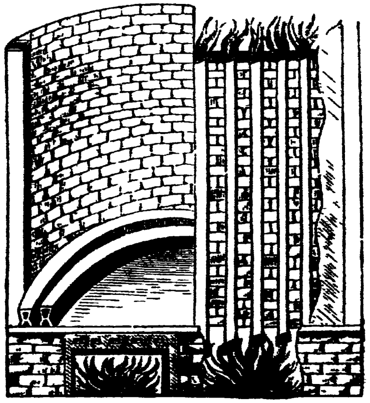
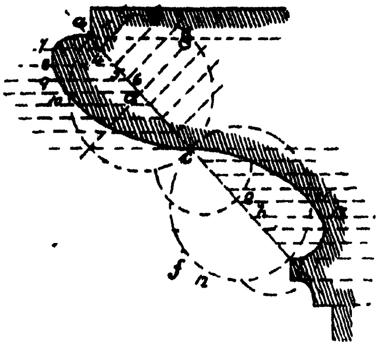


FIG. 6.

MOULDINGS.



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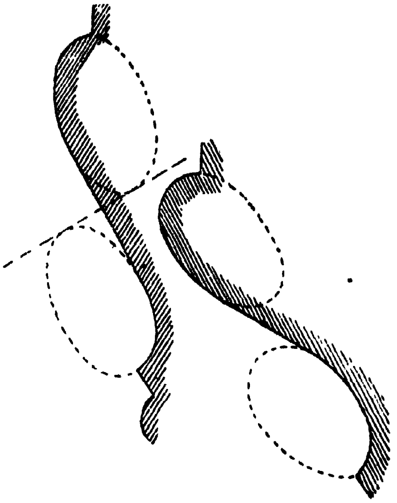

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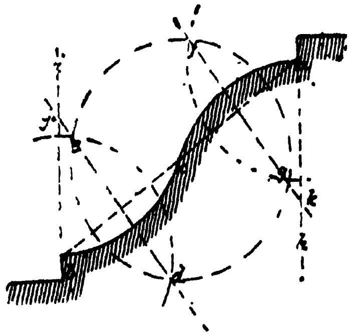

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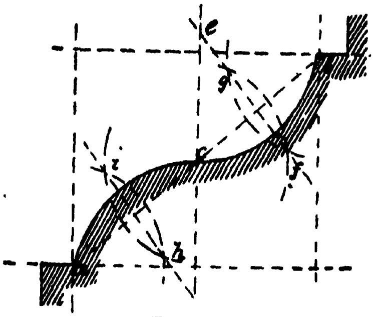

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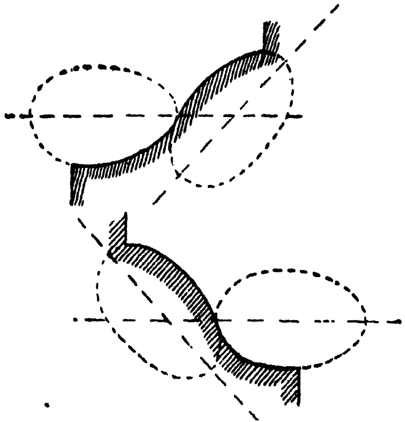

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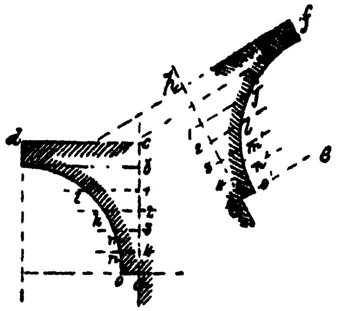

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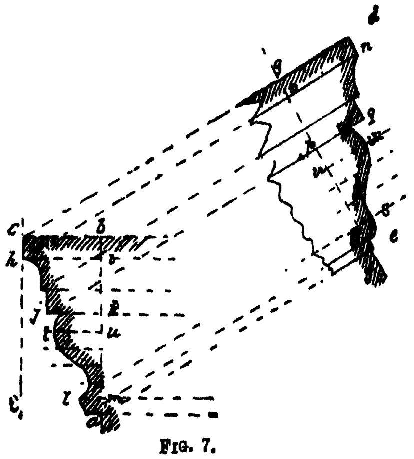

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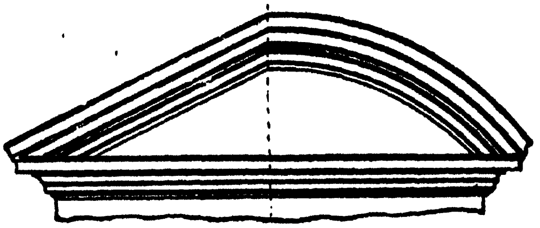
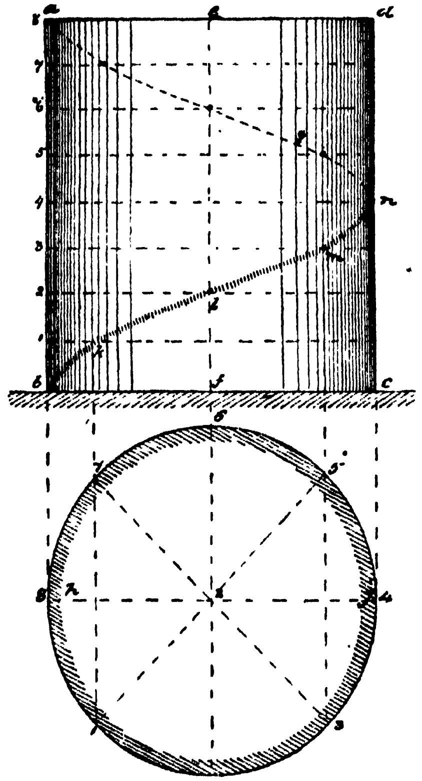


FIG. 8.

Development of Helices and Screws.



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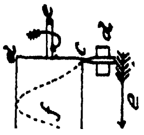

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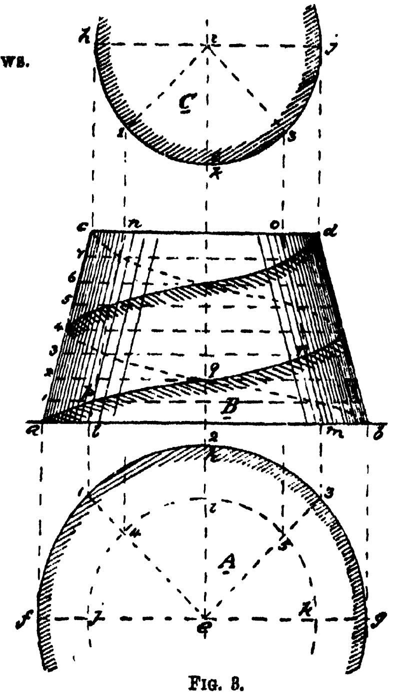


Fig. 3.

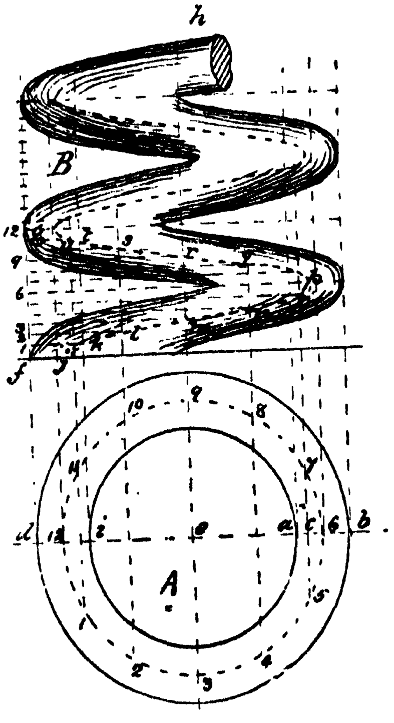


Fig. 4.

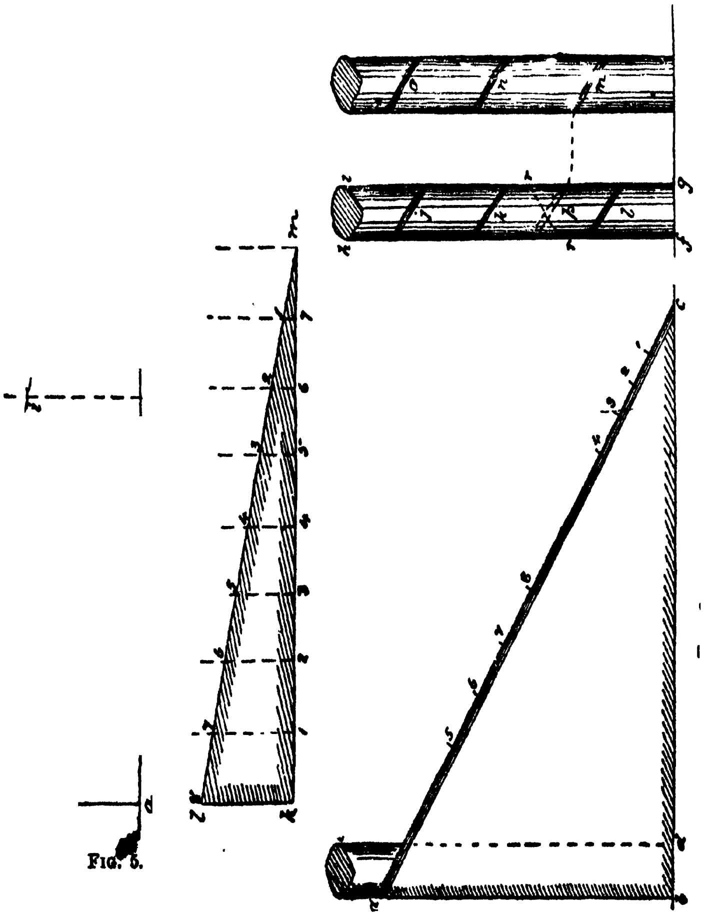
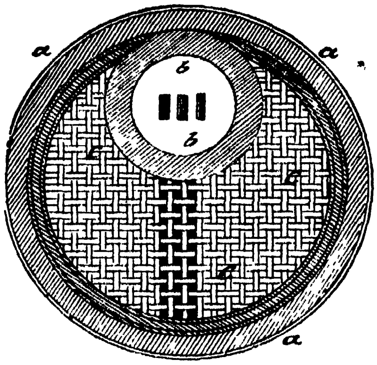


Fig. 5.

[Plate CLXXXII.

THE IRON MAKER (*see Text*).



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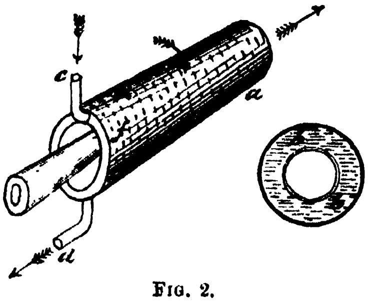

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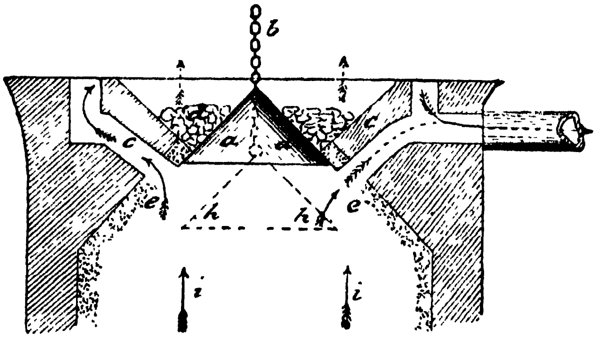
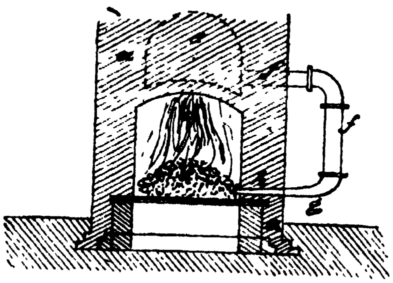


FIG. 3.



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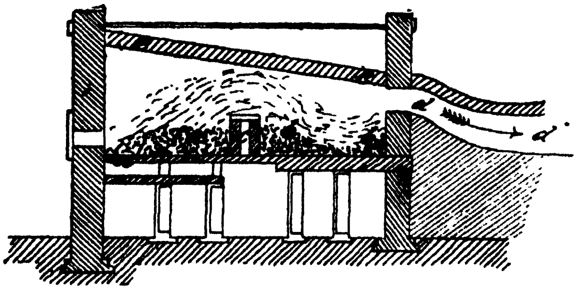


FIG. 6.

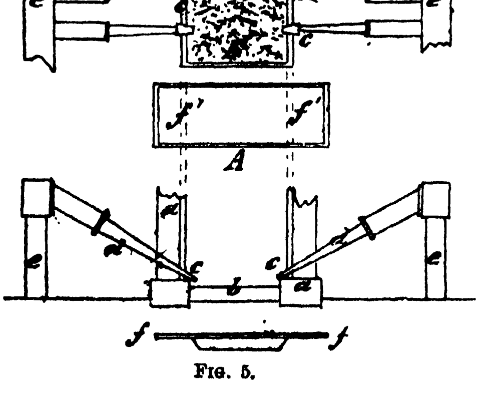
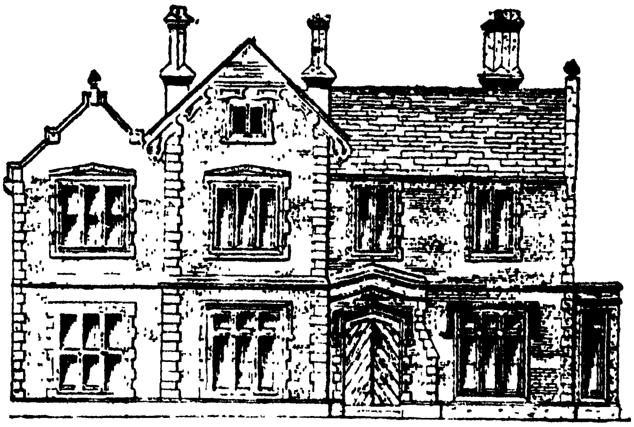


FIG. 5.

THE DOMESTIC HOUSE PLANNER. (*see Text*).

DETACHED VILLA. STYLE—DOMESTIC GOTHIC.



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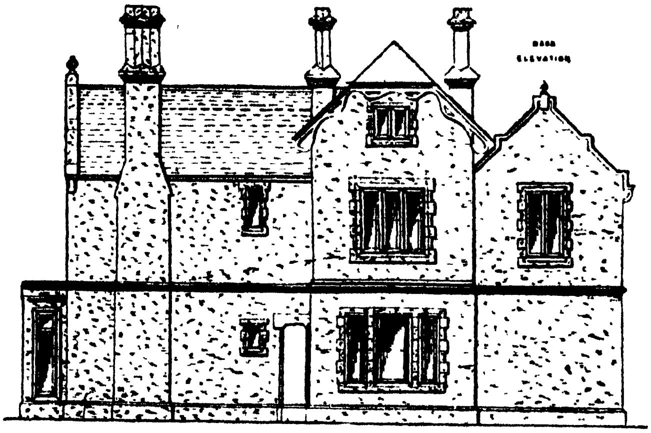

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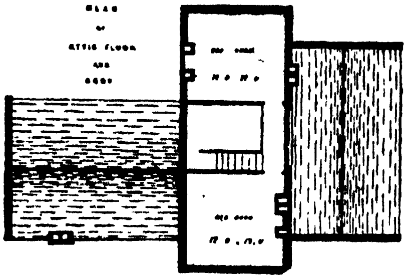

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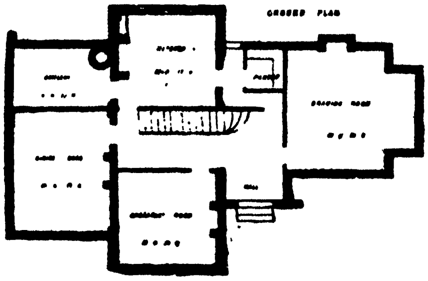

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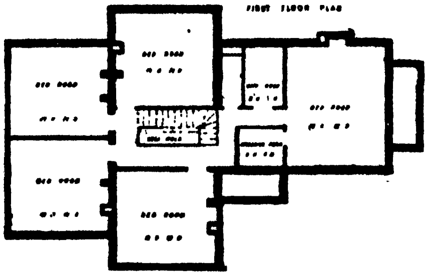


FIG. 6.

THE ROAD MAKER.

HIS WORK IN THE LAYING OUT OF ROADS IN RURAL, SUBURBAN AND TOWN DISTRICTS, THEIR CONSTRUCTION, REPAIR, AND IN THE CHOICE AND USE OF THE VARIOUS MATERIALS EMPLOYED.

CHAPTER VII.

AT the conclusion of the last chapter we described the ordinary form of iron hurdle. In other forms the struts or braces to support them are dispensed with, and the uprights are furnished at foot with three long prongs, something like a digging fork. These when pressed into the soil keep the hurdles moderately steady. And as pressures upon the hurdles tending to "topple" them over vary, one pressure acting in one, another in the opposite direction, the opposing pressures give as a resultant a general steadiness to the whole range. To secure this mutual support the uprights of any two contiguous hurdles are secured together. Wire is often used in combination with wood, this material forming the vertical posts as at *d d*, fig. 6, the wires stretched between them as at *e e*. These are sometimes passed through holes bored in the post at intervals in their height, the whole length being tightened up here and there in the length of fencing. This makes the neatest finished fence. But the other method, of securing the wires *e e* to the posts *d d* by merely twisting them round, gives a stronger fence, as in fixing the several lengths at different heights the strains or pulls upon them may be so adjusted as to give considerably greater strength to the whole than by the first method above described.

Fences of Roads (*continued*).—Timber Work.

But by far the most frequently used material for fences to roads where quickset or other kinds of live (or growing) fences are not planted is wood or timber. And this is also the material most in keeping with the surroundings, at least in rural districts. Even the simplest or rudest timber fence looks more appropriate in such places than the most expensively constructed iron or wire fence. The latter, even at its best, and from the very characteristic of uniformity, looks straight, formal, and, so to say, cold when contrasted with a timber fence. Æsthetically considered, the timber fence is appropriate to its position, the iron fence far otherwise. Although as a rule there is a bald uniformity in the style of timber fences, the material nevertheless lends itself readily to any adjustment calculated to please the eye. There is no reason why timber fences should be ugly, or always erected in the same uniform style, even if that style cannot be called ugly. There is every reason, indeed, why they should not be so constructed; and a pleasing variety might be introduced into the fencing of a long stretch of road by having designs to alternate according to the peculiarity of the part through which the road is passing.

Where private property butts upon or comes up to the margin of the road footpath, it is generally secluded from the public gaze, or secured from the trespassings of wayfarers on the road, either by the expensive stone or brick wall, or, where saving of money is an object, by timber paling. This is made up of flat boards, secured at their upper end, or near it, and sometimes in the middle of their length or height, by being nailed to horizontal battens stretching between the strong vertical posts driven into the ground securely at intervals. The ordinary "wood paling" cannot be said to be a pleasing feature in the landscape, looking at the road and the ground through which it passes as a part of this. Although not a whit less or more exclusive—or excluding—in the motive for its construction, it has not the same claim to the respect—the business respect—of passers-by which the more solid brick or stone wall possesses. This latter kind of excluding fence is at all events respectable, because it is costly—in the same sense as a celebrated author quotes some one who affirmed that a man could be in his estimation nothing less than respectable who kept a gig, for gig-keeping involved money-having, or, at least, money-spending. But a paling is, on the other hand, a shabby-looking contrivance, for, while it betrays on the part of its constructor as great a desire to be exclusive or excluding as on his who has built a wall which costs pounds for every yard-run where his has cost but pence, it plainly tells that he has not the cash, or does not care to spend it, for the nobler material. And so far neither poverty nor stinginess are deemed by the world to be respectable.

Still, much can be made of the wood paling to redeem it from the bald plainness or ugliness which unfortunately is but too common also. The reader desirous to learn how paling is treated by Continental workers in timber so that it possesses some claims at least to artistic design, may consult the series of papers in this work under the head of "The Ornamental Designer in Wood, Stone, and Metal Work," in which there is a section devoted to timber work ornamentally treated. We give the baldest and barest of hints here—derived from the papers here alluded to —as to how the ordinary wood paling can be made to look a "shade" better by treating the upper ends as at *a a* in fig. 6 (vol. ii., p. 309), or as shown in a slightly advanced design at *b*. Other methods which can give by their adoption real beauty to what is almost invariably lacking in it, will be found illustrated in the papers above referred to.

Fencing at parts of the road other than that bordered by private property, which in this country is usually excluded from the gaze of public wayfarers, is of the ordinary open kind familiar to all. But on the mere position of the individual pieces which make up the fence as a whole depends the fact whether it will be plain or ugly, or have at least some pretensions to that which can please the eye. With precisely the same materials one man will construct his fence very much as a savage would do the work, by "sticking" in his pieces of timber along the line of fence; the only point in which his work differs from that of the savage being that the pieces are upon the whole accurately spaced out, so as to leave nearly equal intervals between them, and that they are all in a sufficiently straight line. Another man, taking the same kind of pieces, will so construct his fence that it may show some few evidences of thought being given to the arrangement to produce a certain effect; or he may, as some do almost intuitively, so arrange his pieces that he arrives at what is in fact a good design, artistically considered. Some of the ways in which timber fencing may be arranged are given in illustrations figs. 8 to 11 inclusive. These are merely suggestive in a very bald way; the reader must consult the papers on "Ornamental Wood Work," above alluded to, for more elaborate examples based on certain principles of design and construction. Figs. 8 and 9 show the simplest methods of constructing or erecting timber fences. In fig. 8 the posts, as *a* and *c*, bounding the footpath *d*, with its gutter *e*, are placed vertically, with the timber chiefly running horizontally. In fig. 9, in the diagram to the right, the whole nearly are vertical, as *g*—thicker or stronger posts, as *f*, being given at considerable intervals—a horizontal tie or batten, *h*, being used to connect the whole together. This may be somewhat pleasingly modified by the arrangement as shown to the left of the same figure—the stronger posts, as *a*, *b*, being placed at wide intervals, half of the thinner ones, as *d*, between *a* and *b*, only passing up beyond the first horizontal tie, the other half reaching only to a point, *e*, a little above the lower tie or stretcher batten. In fig. 10 the angular arrangement is illustrated in the sketch to the left, this being in single diagonal, *e*,—the lower ends of the pieces being inserted slightly in the soil, and secured to the tie or horizontal batten, *b*, between the verticals or struts *a a*. In the sketch to the right the diagonals are double crossing, as at *d*.

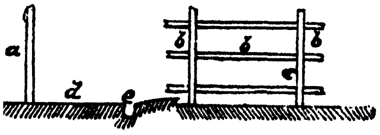


Fig. 8.

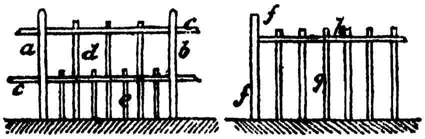


Fig. 9.

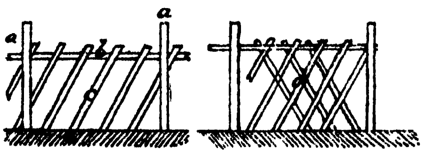


Fig. 10.

Road Fences (*continued*).—**Rural or Rustic Timber Work.**

A style of fencing capable of giving exceedingly attractive results is that in which untrimmed or undressed branches of trees are used. Their employment is merely suggested in the sketch in fig. 11 The whole spaces between the posts, as *a a*, or *d d*, may be filled up with other branches, as at *b c*, or the fence may be arranged at the bottom part as *g g*, and finished at top as at *h h*. But the combinations of which natural branches are capable are endless; and while all look well, some can be hit upon which will be more than usually attractive. For further information on and illustrations of this very interesting specimen of timber construction, applicable to a wide variety of purposes other than road fencing—as to garden structures—the reader is referred to the papers already alluded to.

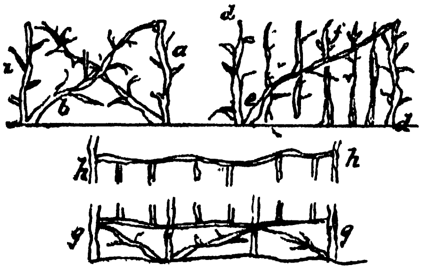


Fig. 11.

Fences of Roads (*continued*). **Stone and Brick Walls.—Retaining Walls.**

In a preceding paragraph we alluded to the bounding of roads with stone or brick walls, when the road passes along or through a private property. On level ground, or in shallow cuttings, the building of walls presents no very special difficulty—good, sound, and honest workmanship being what is chiefly demanded of the mason or bricklayer. But in passing through deep cuttings, whether these bound private property or not, specially constructed walls are required for the preservation and safety of the road and the passers-by upon it. Walls used in such situations are called technically "retaining walls," and the various points to be attended to in their construction will be found detailed in the series of papers in this work entitled "The Stone Mason," etc., etc.

THE LAND DRAINER.

DRAINAGE OF LANDS OR SOILS SUITABLE FOR THE CROPS AND LIVE STOCK OF THE FARMER.—ITS HISTORY, PRINCIPLES, AND PRACTICE.

CHAPTER VI.

AT the end of preceding chapter we stated that the system of draining introduced by Parkes was entitled one of deep draining. The depth, ranging from three to four feet six inches, especially in clay lands, was the peculiar feature. Some may at first sight be disposed to think that, from the very character of a clay soil, it was the last in which a great depth of drain would be useful. But it is precisely in clayey soils that the benefit of deep drainage is most marked; the water, contrary to popular notions, passing through the dense clay with certainty and indeed comparative ease. How this arises we shall in due course see. Having thus brought up to date the historical fragments—for but little more than detached portions are recorded—we have at command on the subject of land drainage, we proceed now to glance as briefly at some points connected with the formation of soils, and with the manner in which water passes through them to drains placed in the interior at varying distances and depths of their mass or general body. This statement will tend to clear up doubts held by some as to whether deep drainage is really beneficial to soils as crop producers.

The surface of the earth capable of supporting vegetation is formed by the deposit of the *débris* or disintegration of rocks. The soil of elevated ground consists principally of the *débris* of the rock on which it rests, the disintegration of which has been effected by the action of the elements. The surface of lower lying localities is composed of the *débris* of higher lying districts conveyed to their present position by mountain torrents, and vary in the composition of gravel, sand, and clay, frequently mixed with boulders or worn fragments of rocks from which the deposit originated. Such deposits have been formed in remote ages, far beyond the limits to which history extends; and these have been not inaptly called *drift deposits*, and they are frequently found of great depth, incumbent on rocks to which they have no relation. Another description of formation is of a much later period. It is still at the present time going on, generally occupying a lower position than the drift formation spoken of, occasioned by a less violent action of water inundating the surface, from which solid earthy matter held in suspension is deposited, and is called *alluvial deposit*. The last-mentioned is the manner by which recent clays have been formed —a soil which, of all others, receives the greatest and most marked benefit from being drained.

On examining a dry block of clay, it will be found to be divisible into thin horizontal laminæ, or layers of plastic earth, with partings of sand between the laminæ,—thus showing the manner in which clay beds have been formed. The calcareous or siliceous matter composing the sand being specifically heavier than the minutely divided particles of matter composing the plastic earth or clay, the former is deposited from the water sooner than the latter, and the coarse sand separated earlier from the water than that composed of smaller particles. This, from a succession of inundations, has formed beds of clay soil of considerable thickness, and even sometimes of great depth, the laminæ varying in thickness, both in plastic matter and gritty partings, and in fineness and coarseness of the latter, according to the circumstances of the depth of the quantity of solid earthy matter contained in and the velocity at which the inundating water had moved.

The clay soil above described, however homogeneous in its nature it may appear to be, is always capable of being split into horizontal laminæ, and, when dry, on the surfaces of their beds being rubbed, sand, however fine it may be, will be found to compose the partings.

The difference between the surface or super-soil and the sub-soil is, that the former is mixed with organic matter, to a greater or a less extent, largely impregnated with atmospheric air, and contains water to support vegetation: whilst the subsoil, when composed of clay, is too compact to admit air or water, and is generally dry, unless from springs it is wet to such a degree of redundance as to be obnoxious to vegetation: hence it is by the admission of air and water to the subsoil, or by the escape of redundant wetness, thereby preparing the subsoil for the nourishment of plants, that draining is so marked in its effect on soils resting on a clay or retentive subsoil.

The laminæ in clay subsoils, as they lie upon one another, may be compared to leaves in a book; and although the matter of clay is impervious to the passage of water from one lamina to another previous to draining, yet on a cavity being made in a subsoil containing water by which it may escape, or where solar heat is admitted by the medium, the clay shrinks horizontally, and the laminæ break into a network of vertical fissures, by which water can pass through them until it reaches the cavity spoken of.

Very important circumstances are frequently lost sight of in cutting trenches for small or collecting drains. These are, first, that the trench should pass vertically through the laminæ and their partings before spoken of; secondly, that the water in its passage through the subsoil, by the fissures before mentioned, to the level of the duct or cavity, passes along the partings to the sides of the trench, and falls down thereby to the duct; and, lastly, that in filling the trenches the disturbed soil never perfectly unites again with the sides of the trench, there always being an interstice from the surface to the drain, by which the water, bleeding, as it were, from the permeable partings of sand between the laminæ of clay, can pass to the drains. The soil filled into the trench losing its laminar arrangement, becomes a puddle plug therein quite impervious to the passage of water. Hence it is that water is more apt to stand directly above drains than in any place between two of them; and, consequently, the reason for not putting drains in hollows, as in the furrows or valleys between the ridges of ploughed land. The only reason that can be adduced for putting drains in furrows is not of much, if of any, account on the score of economy in a saving of the depth of cutting, as the depth of drains, when they properly cross furrows, should always be measured at the mid-haunch of the ridge, and not either at the crest of the ridge or at the bottom of the furrow.

As to the depth at which drains should be made no specific rule can be applied, as circumstances may require a difference of depth, not only in contiguous fields, but even in the same field, necessary. It may, however, be remarked, that failure in efficiency in draining never arises from drains being too deep, but frequently from their being too near the surface. Thus the ducts may be laid above the principal water-feeders in the subsoil, or the ducts may be at an insufficient depth for the water to acquire a force of gravity in its fall to overcome the power of retention of a deep soil containing a large proportion of organic matter until supersaturation, which may be a greater quantity of moisture than to be favourable to healthy vegetation; in either case, the drains will obviously be of little or no use. A drain, however, may be deeper than necessary, and therefore improper on the score of economy.

Now, since drains may be too near the surface to be efficient, and if deeper than necessary needless expense will be incurred, the proper depth of drains in every particular case can only be correctly determined by sinking trial pits into the subsoil. In making such trials, the pits should be sunk to different depths, noting which draws most efficiently, and adopting the least depth producing the greatest effect.

As the subsoil may vary greatly in its nature in the same field, so the depth of the drains may be required to be varied to produce the best effect at the least cost. As a general rule, in regard to the depth of drains, the more compact the subsoil in which the drains are to be laid the deeper should be the drains; since water-feeders in a compact subsoil being smaller than in that of a more open nature, it will require a greater number of feeders to be in operation in the former than in the latter case to discharge the same quantity of water in an equal period of time. It is a fact established by the results of repeated experiments, that, under equal conditions as to the nature of soil and distance apart, drains at a depth of four feet are more efficient in their action than those at a depth of three feet in the proportion of 8 to 5, or in the deeper drain discharging eight pints in the same time of the shallower one discharging five pints. In estimating the comparative cost of draining at different depths, the area of the surface is not the true measure of economy, but the mass of soil in cubic contents drained should be the subject of comparison in deciding this very important matter.

Whenever the collecting drains are at different depths, the receiver or main drain into which they are discharged should be sufficiently deep to receive the water from the deepest of the small or collecting drains.

The proper depth of drains being determined by the means pointed out in the foregoing remarks, their proper distance apart may then be determined from their depth, and the nature of the subsoil in which they are to be laid.

The distance apart at which drains should be laid in terms of their depth, and according to the different kinds of subsoil, are as follows, viz.:—

Nature of Subsoil.	Distance apart of Drains.
Strongest clays . . .	4 to 6 times depth of drain.
Clay mixed with nodules of gravel	6 to 8 „ „ „
Clay with seams of gravel or sand, according to the thickness of such seams .	8 to 10 „ „ „
Sandy or gravelly subsoils .	10 to 12 „ „ „

In drains not exceeding six feet in depth, the foregoing rule will be found to agree pretty accurately with the most successful practice; but at greater depths—which, however, are seldom required in ordinary field draining—the distance apart of the drains, under different circumstances as to subsoil, must be determined by the experience of the engineer or drainer designing or conducting the drainage.

By many persons the system of draining about to be treated of has been, as we have seen, attributed to the late Mr. James Smith, of Deanston, in Perthshire, Scotland, as the originator. Such, however, was not really the case, as the system in question was in partial use in several localities in Great Britain at an early period of the present century; and it was not until about 1824 that Mr. Smith, with great enthusiasm, directed public attention to the great benefits to be derived from it in increasing the fertility of the soil; and without his advocacy it might, perhaps, have continued for a length of time to be generally unacted upon,—so that, although he may not be in reality the original inventor, yet, at any rate, great merit is due to Mr. Smith for having enforced the general adoption of the modern system of thorough draining.

THE FARMER AS A TECHNICAL WORKMAN.

His Tools, Implements, Machines and Materials.—The Principles of his Work in its Various Departments.

CHAPTER VI.

We stated at conclusion of last chapter that the plough, the harrow, and the roller constituted for long the only—and formed the rudimentary—implements of agriculture. The introduction of the drill system of husbandry by Jethro Tull, to which we have in Chap. IV. (vol. ii., p. 125) already alluded, gave another development to the mechanical appliances of the farmer, substituting for the rough-and-ready broadcast system of scattering the seed over the surface of the ground by hand, the corn drill, with the precision and accuracy with which it laid out the lines of seed, and proportioned to each its due amount, according to the requirements of the soil, or what the farmer deemed necessary. Then, although at a much later date, came the introduction of the horse hoe, a corollary or natural sequence in mechanical invention to the corn drill, the one being supplementary to the other; and the complete working of either one of which depended upon the perfection of arrangement of the other. The "corn drill" and the "horse hoe" may be said to have revolutionised one department of field work,—the first giving the accuracy of parallel lines to the growing crops, which admitted of the working between them of the tines of the hoe; these in turn not only clearing away the weeds, which, growing between the lines, if left there would have withdrawn largely from the soil and its crops the fertilising constituents, but opening up the soil and leaving it exposed to the ameliorating influences of the atmosphere. What part those influences play in the practice of crop culture, we shall see in some cases directly, but in others more or less indirectly, as we proceed.

A Knowledge of the Principles which affect the Growth in Relation to the Soil Essential in carrying out a Good System of Working or Cultivating it.

In the preceding paragraph we have offered a few introductory remarks on the implements of farming, and how these were connected with the general work of cultivation. We shall see as we proceed how the principles upon which these implements depend for their best work are influenced by what may be called the true requirements of the plants. A knowledge of the principles which affect the culture of crops, or of the laws upon which they depend for their healthy existence, must be useful to the farmer, not merely in carrying that culture out in all its details, but in determining how far the implements he uses are calculated, or otherwise, to aid him in this, which is indeed the most important department of his work. For although he has to concern himself with the breeding, rearing, and feeding of live stock, the animals making up this must depend in great measure on the nutritious and valuable condition of the crops by which they are largely fed. On the other hand, a knowledge such as this cannot be otherwise than useful and valuable to the mechanic in rural districts, a large portion of whose work lies in the construction of the implements which the farmers of the district require.

Relation of the Machinist to the Farmer.

Important in every one of its issues as agriculture is, it is somewhat humiliating to think that it of all our industrial arts has been the last to receive the attentions and benefit by the labour of our scientific men and of our engineers and machinists. It is idle to say, as has been so widely and repeatedly said, that this apathy or indifference of the scientific and technical classes has been caused, promoted, and long maintained by that of the farmers themselves as a body. For one has only in refutation of this charge to point to the fact, which is indisputable, that no sooner had science and the technic constructive arts offered their aid to farming than this was gladly received and readily availed of—so readily and so largely that we believe that no class of men interested in the progress of any branch of industry within so short a space of time availed themselves of so many of the aids offered them by those classes, by which that progress was promoted, as the farmers. So far from being indifferent as to what technical science could do for them, those who know them best—and the writer of these lines believes he knows them pretty well—are inclined, having good reasons therefor, to blame them for purchasing too much machinery rather than for purchasing too little. We venture to say that machinists found few customers so easy to persuade to the buying of their machines and implements as the farmers, and men of science few who so eagerly availed themselves of what they offered in the way of advancing farm practice.

If proof be needed of this, it can be had of the most convincing kind by a mere reference to the importance of the agricultural manure and implement trades, as a factor in the general sum of national wealth. The writer is old enough to go back a goodly number of years; and he can well remember, at the period of his apprenticeship, how few were the factories and workshops which were concerned wholly or chiefly in the making of farm manures and farm machinery—using these terms in their widest acceptation—and how trifling in number and value were the productions they turned out. Now the position of these "trades" is such that, whether we take the number of those engaged in them, the variety and extent of materials and work they produce, the material they use up, the number of men they employ, or, last, not least, their business capacity, not only as able in their respective departments, but as energetic and specially enterprising commercial men, they are second to none in the kingdom. Let those who know what was the condition of the agricultural manure and implement trades, as represented by their "exhibits" at shows alone, at the first meeting of the Royal Agricultural Society of England, at Oxford, and what it is now, as represented by them at the latest of the Society's shows, speak to this point. And yet the period between the two is comparatively the veriest trifle in the history of a people, which takes centuries to develop.

But if so much progress has been made in the past, aided, as it has been, by the work of the man of science and the mechanic, we believe that vastly more will be made in the immediate future, if only they will lend their aid to make that progress sure. We are of those who believe that we have as yet but touched the edge or outer fringe of the vastly wide field which lies before the nation in the more scientific cultivation of the soil. Nearly the whole expanse of this field is literally before us, and if it is to be rapidly explored, it will and can only be done by a perfect and thorough combination of the work of the man of science, the engineer, and the farmer. Disunited, one or other of these will do little more than has been done; and, much as that comparatively has been, it is not easy to confute with facts the statement that it is as nothing compared to what is yet to do before we can say we have obtained—even by an approach—the maximum of the fertile resources of our soils. But this combination of effort must be directly based on the actual conditions connected with the practice of farming—that is, of the *soils* with which it deals, and the influences which can be brought to bear upon them.

The Conditions of the Soil Essential to Plant Life, required to be brought into Existence by Machines and Implements in Connection with Drainage, etc., etc.—The Sources of Plant Constituents.

In naming these, we can of course do little more than point out generally some of the leading features of the question. All plants derive their constituents from two sources: first, from the atmosphere; second, from the soil. The atmospheric comprise two classes of fertilising agents—the air and water. The influence of the atmospheric agencies are very marked, although for long they were much overlooked, and are, indeed, still overlooked by many. Land which is exhausted or worn out, if allowed to remain for a length of time exposed solely and only to these atmospheric influences, will become again fertile; and if subjected to cultivation will again raise fine crops. To admit of the action of these influences, it is obvious that the soil must be in a certain condition; and it may be in a bad, it may be in a good condition. If it is hard on the surface, if the particles are closely compacted together, it is beyond a doubt that the air and rain cannot possibly penetrate the soil in such a complete way as if the surface were open, the particles loose and friable. The other source of plant fertility we have named is made up of the constituents which are either present in the soil or added to it in the form of manures of various kinds. These constituents are very unequally distributed: one part of a field may, indeed, be almost destitute of certain constituents valuable for a certain crop, while another part may have more than the crop requires. This inequality in the constituents present naturally in a soil gives rise to many puzzling circumstances in practice, from its being overlooked or unknown, and also to a diversity of results in agricultural experiments, and the experience rising out of them. The same remark may be made of the constituents supplied to soil through the medium of manure: these may be very unequally distributed—one part of the soil receiving the maximum, another the minimum supply, while a third may in fact receive none at all. These facts point to the benefit of a thorough mixing of the soil, so as to render it of as even or uniform a quality as possible. It may be accepted as the statement of a fact that there is practically no soil in which the fertilising constituents present naturally in it, considered as a mass, are evenly diffused throughout the mass. One part will be always richer than another. Some parts may, as indeed is often found in practice to be the case, be without these fertilisers; while other parts may have a superabundance of them. Hence, any method of working which will mix the soil so as to distribute these fertilising constituents so that the whole may have as equal a share as possible must be beneficial, as giving equal chances throughout of a crop pretty uniform in character and value. Further, although the constituents in the soil may be abundant as regards quantity, and all that is required as regards specific quality, still they may be in such a condition or state relatively to one another, and to the plants which are to draw upon them for nutriment, that they may not be available by them; and, still further, the soils may not be in a condition to absorb or take them up. Without going into the minutiæ of the matter, suffice it is to say that soils, when finely divided as regards mechanical conditions, are in a condition better fitted to absorb the fertilising matter of the inorganic constituents present in the soil, than when they are in a dense, close, and compact condition.

Power of Rootlets of Plants in absorbing or taking up the Fertilising Constituents of the Soil.

This is so obvious that it would seem scarcely to require to be studied; but, obvious as it is, that it is nevertheless overlooked by many farmers is proved by the very condition in which they keep their soils.

THE TECHNICAL STUDENT'S INTRODUCTION TO THE GENERAL PRINCIPLES OF MECHANICS.

LAWS AFFECTING NATURAL PHENOMENA—MATTER AND MOTION.

CHAPTER XXI.

Centre of Gravity in Moving Bodies.—Rolling Motion.

WE now come to the phenomena connected with the changes of the centre of gravity in bodies, as in "rolling and sliding movements." When a ball or sphere, *a b*, or a flat disc, perfectly circular, is placed upon a perfectly level plane, as *c d* in fig. 14, the resting point of its surface upon the plane *c d* is precisely under the centre of gravity, *g*. That is, the line, *g f*, of direction of gravity or of the attraction of gravitation, which is always vertical, as we have already shown, cuts or passes through the point on which the sphere rests, or on which it comes in contact with the plane surface *c d*. If force acting upon the side *a* in the direction of the arrow *e* causes it to roll along the plane *c d*, the centre of gravity moves along in a line parallel to the surface of the plane, there being no rising or lifting movement of the centre causing it to describe or take a path more or less curved, as in the case of solid bodies such as are illustrated in the preceding figure. It is this condition of the sphere or circular disc in relation to the plane or level surface along which it rolls, which, not necessitating the expenditure of any force, or lifting or raising the centre of gravity, as in the case, say, of pyramid *f g o*, fig. 9, which makes circular or spherical bodies to be so much more easily moved along flat or level surfaces than bodies with flat sides. It is this motion, technically termed "rolling," which gives the value to carriage wheels. The type or original form of the modern carriage wheel is the roller pure and simple, which in early times was used in the form of the branch of a tree, chosen for its surface being more perfectly cylindrical than other branches. This roller would in process of time be more and more shortened till at last the disc or wheel would appear; and when this was fixed or movable, or allowed to rotate on a fixed axle, an enormous advance in mechanical progress was made. As in the case of the "crank," that other wonderful discovery or invention in mechanical arrangement, so in that of the "wheel" for carriages to be dragged along by animal force, we know nothing of the inventor: so true it is that in a large majority of cases the world knows not to whom it is indebted for inventions simply priceless in value.

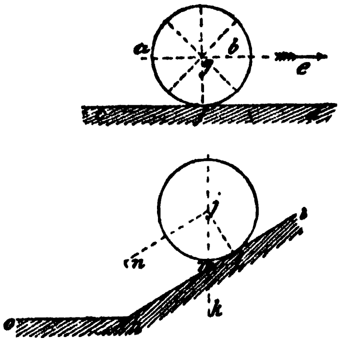


Fig. 14.

We have said that in the case of a sphere or flat circular disc, with parallel faces and therefore a flat periphery, the line of direction, *b c f*, fig. 9, or of centre of gravity, *g*, is directly over or will fall upon the point *f*, on which the body rests, as the level plane *c d*; and if we suppose a tendency for the side or point *b* to drop, there will obviously be a like tendency on the side *a* to drop also, and as both are equal in intensity they balance each other, and the sphere or disc therefore remains at rest. But if, in place of resting upon a level plane *c d*, as in the first diagram, the plane is inclined, as *h i* in the second diagram, we have the conditions altogether changed: the line of direction of gravity, or of the attraction of gravitation—in all cases, let the young student remember, vertical—in this case, represented by the line *j k*, no longer coincides with or cuts the point of contact of the sphere with the plane *h i*, and which point is at *l*, but is just so much in advance of it as at this point *m*. And as, in virtue of the attraction of gravitation, the body has always a tendency to fall to or reach the lower point, the centre of gravity, *j*, moves in the direction of the line *j n*, parallel to *h i*; in other words, the sphere drops, or, in technical and popular language alike, it "rolls" down the inclined plane till it reaches and rests upon the level plane on which, after a period when its "momentum" has ceased, say at point *o*, it rests precisely as it did under the conditions as illustrated in the first diagram above.

If the body, in place of a sphere, were a cubical one, as in *j k l m*, fig. 7, it would not roll down the inclined plane, but "slide" down; and the reason why, so to say, it would prefer the sliding to the "rolling" motion is simply this, that before it could roll it would have to turn over from one side to the other, and always turn over upon a corner, as *m* or *j*, as on a centre; but this would involve, as we have seen in a preceding paragraph, the raising of the centre of gravity in a high curved path (see fig. 11), and this raising would obviously take or absorb more of this impelling or propelling power caused by the slope or incline than the mere act of sliding down the plane would require. Hence the cube would "slide," not roll, down the plane as the sphere would. But to show how the "conditions" under which bodies are placed influence the phenomena they exhibit, it is necessary here to explain why a body square or rectangular in section, and therefore with flat surfaces, will roll, not slide, down a sloping surface, as many of our young readers may have seen bodies of this or of very irregular section do. Where the incline is very great, or the surface, in common language, very steep, and where the surface of the body is so very rough, or that of the inclined plane, that great friction is created between the two, a less degree of the impelling force may be required to turn the body over in its career than that required to overcome the friction between the flat side and the surface of the incline; as the easiest course is in natural phenomena taken, the body rolls down in preference, so to say, to sliding down. But even in cases where a square or flat-faced body begins and takes a certain part of the downward course with the process of sliding, it might be changed into a rolling motion. For as the body would acquire momentum as it advanced along the slope or incline, it might reach some obstruction on the plane which, if strong enough or firmly fixed enough to give way, would so act that the corner of the body catching it would be arrested, and the momentum would cause the centre of gravity to be raised, and the object would, so to say, "topple over," precisely as shown in figs. 10 and 11, and when once begun this toppling might be repeated and the rolling motion would be continous till the base of the incline was reached. The rolling motion of a body square or irregular in section must be of necessity the reverse of smooth or easy; it, is, in fact made up of a succession of bumps or blows as each corner or projecting point comes round in contact with the surface of the plane along which it rolls. In the case of a sphere or disc or a cylinder, the rolling is smooth, for all the lines radiate from the centre of gravity in equal directions, and are all of equal length, as shown in first diagram, fig. 14; so that there are no corners, protuberances, or projecting parts. We have been thus particular in describing the points taken up in this paragraph, for, simple as their phenomena may seem to be, it is not every young reader who knows the principles upon which they depend, and can explain them; and, as we have said before, and it is worthy of being said again, he should gain the habit of thoroughly understanding simple subjects before passing to more difficult ones.

The Centre of Gravity of Rolling Bodies (*continued*).

We have hitherto considered the phenomena of rolling stones in relations to the centre of gravity, in which the body, as the sphere or globe, the circular flat disc, or the long cylinder, is of equal substance throughout, and therefore any two points at opposite ends of a diameter of equal weight. But we can conceive of a sphere or disc or cylinder having its substance or material unequal—as, for example, a wooden globe or disc with a mass of lead at one point of its circumference. A body thus made is in popular language said to be "lop-sided"; and this is illustrated in the first diagram, fig. 15, in which the wooden disc, *a* has a lump of lead or heavy metal *b* at one part of its periphery. From the mass of a body, having, as we have seen, a tendency always to seek the lowest point, a disc so made, when allowed to rest upon a perfectly level plane, as *c d* in first diagram, fig. 14, would always assume the position as in first diagram, fig. 15, with the weighted part *b* in contact with the plane and directly under the centre of gravity *a*. If placed in the position as in second diagram in fig. 15, with the loaded portion at *e*, the upper part, by very dexterous manipulation, might be so balanced as to remain in this position, in which the central point of weight, *e*, would be in a line with the points *f* and *g*, *f g* being the direction of gravity or the attraction of gravitation. In this balanced position the body would have just as great a tendency to fall over, or to move in the direction of the arrow *h*, as in that of the arrow *i*; and this tendency to fall or move would be made to operate with a very slight force exerted from either side: a slight current of air blowing from side *h* would cause the central point of *e* to pass from the line *e f g* towards *i*, in which case the tendency of the weight *e* to fall to the lowest point, as at *b*, in the first diagram, would bring it round to the side *i*, and would thus cause the disc to advance or roll in the direction of *k*, till it rested in the position as in first diagram at *b*. To roll the loaded disc, as in second diagram, along the level plane in which it rests, or to move it along in the direction of arrow *k*, would be a more difficult task than to move the disc of equal substances throughout, as *a b* in the first diagram. For in the second, before we can make the disc move in the direction of arrow *j*, we have the additional work to do of raising weight *b* (first diagram) in the direction of arrow *d*, also the centre of gravity, much in the same way as already explained. This lifting of the weight at point *g* (second diagram) would continue till a point a little to the right of point *e* was reached, when the tendency of the weight to reach the lowest point, or gravity, causing this weight to fall in the direction of arrow *i*, all the labour of lifting would then cease, and the weight itself, or rather its tendency to gravitate to the lowest point *g*, would do the work of rolling the disc along in the direction of arrow *k*; but if this motion

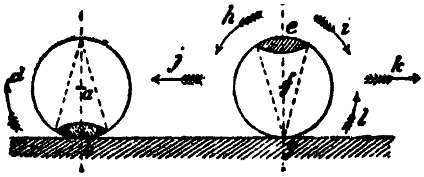


Fig. 15.

is to be continued, the lifting or raising action has to be gone over again after the weight has reached the position as at *g*.

Let us suppose, however, that in place of the loaded cylinder resting upon a level plane, as in second diagram, fig. 15, that it is placed upon an inclined plane, *c*, as in first diagram, fig. 16. Here the line of direction of gravitation falling perfectly vertical, as in all cases it does in the line, falls outside *a*, to the left of point of contact *c*, of the disc or ball in the inclined plane, and hence through the tendency of the weight or mass to take the lowest position, it rolls down the inclined plane in the direction of the arrow *d*, the circular surface of the disc or globe moving in the direction of arrow *e*. But before it can so roll down, the weight or load *c* has to be raised or lifted in the direction of the arrow *e*; and it may be that the force of gravity or of attraction of gravity may be so slight, as compared with the weight of the load at *c*, that it may not be able to raise it in the direction of the arrow *e*, so that we could have the phenomenon of a loaded ball standing or remaining still or quiescent at one point of a surface which nevertheless was inclined or sloping. This state of rest could only be when the relation of the weight of the load to the force of the tendency of the ball or disc to roll down the inclined surface was exactly equal or balanced. And this would obviously depend upon the rate of inclination or the angle of the slope of the surface on which the ball was placed. We have seen that the position of a ball on a perfectly level surface is as in first diagram, *c f d*, fig. 14,—on an inclined surface as in the second diagram at *n m i*; in this latter, the greater the slope or angle of incline, the greater the distance between the point *m*, where the line of direction of gravity, *j k*, cuts the incline, and the point *l*, where the ball will roll down the incline. Decrease the distance *m l*, we lessen this tendency to roll down; for it will be perceived by the young reader that we can decrease and decrease it till at last we change the inclined into a level surface, as in first diagram. We know that a body dropped from a height in free space, whether heavy or light, falls vertically till it reaches the ground, as in first diagram; if the ground is level there it rests, for it has reached the level point *f*. But in first diagram, fig. 16, upon inclined surfaces, it cannot continue, the vertical course being opposed by the substance of the inclined surfaces; it can therefore only reach the lowest point, which is on the levels *i* and *g*, by rolling down the inclined plane, between the vertical or free-space drop and any inclined surface, the two forces being contrary, but equal. Again, we could have the phenomenon, still more singular and to some still more puzzling, of a ball or disc *rolling up* an inclined surface, when all experience tells us it ought to run down it. This, however, is easily explainable on the principles we have already indicated, and it is illustrated in second diagram in fig. 16. Here we have a loaded ball placed upon an incline, the tendency which naturally it has to roll down the incline being represented by the distance *k l*. But if we place the loaded ball somewhere in the position as shown in the diagram, and if we have the weight of the loaded part, as at *m*, so that it is greater than the force represented by the distance *k l*, the weight will fall to the right in the direction of the arrow *n*, raising the centre *j* and making the ball to appear as if rolling up this incline in the direction of the arrow *o*. But the moment the weight reached the point corresponding to *c* in first diagram, fig. 16, or that point where its force, so to say, was overbalanced by the force represented by the distance *k l*, second diagram, gravity would then cause it to roll down the incline till it reached the lowest point, which would be somewhere on the level line *i*, and that at which its rolling would cease to act and that of gravity and friction control and bring it to rest.

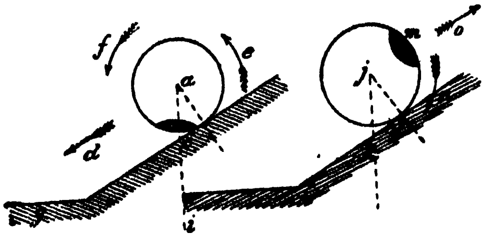


Fig. 16.

Centre of Gravity, Rolling Motion, Carriage Wheels (*continued*).

Carriage and cart wheels revolving freely on fixed axles as centres owe their value, in making traction on roads easy, and at a very much less expenditure of horse-power than when running on sleds, to the principle we have explained in connection with rolling bodies, as balls or spheres or circular discs, as in connection with the diagrams in fig. 16.

A cart or carriage wheel is, in fact, a circular disc, only that for lightness, as well as being most pleasing to the eye, the face of the disc is not solid, but has, as it were, spaces cut out on it, radiating from the centre to the circumference, leaving solid parts between two contiguous spaces, the solid parts corresponding to what are technically called the spokes or arms of the wheel, as in the first diagram in fig. 12, *ante*. The spokes all terminate in a circular part in the centre, which is called the "hub" or "centre," and in the centre of this is the aperture, containing in practice the "axle-box" or bush by which it is placed on the journal or turned end of the "axle" or "axle-tree."

THE STEAM ENGINE USER.

THE DIFFERENT CLASSES OF ENGINES USED CHIEFLY FOR MANUFACTURING AND AGRICULTURAL PURPOSES.—THE LEADING DETAILS OF STEAM ENGINES—CONSTRUCTIVE AND OPERATIVE.—THEIR PRACTICAL WORKING AND ECONOMICAL MANAGEMENT.

CHAPTER XVI.

WE stated at the end of last chapter that the rings of Mr. Ramsbottom's piston must be made very light, for, as he says in a paper on the subject, "three separate grooves, each $\frac{1}{4}$ inch wide, $\frac{1}{4}$ inch apart, and $\frac{5}{16}$ inch deep, are turned in the circumference of the piston, and these grooves are fitted with elastic packing rings," thus presenting a much less area to rub against the side of the cylinder. This form of piston is almost invariably to be found in locomotive engines and in high-speed stationary engines.

The Governor, as its name implies, governs the speed of the engine, by means of the momentum given to it by the speed of the engine. The earlier form of governor, shown in fig. 33, consisted of an upright spindle which carried two levers jointed to it at its upper end. To the lower ends of these levers were attached heavy weights, which, as the spindle revolved quickly or slowly, flew farther from or drew closer to it. By means of other levers and rods this motion was communicated to a kind of valve called a throttle valve. The action and construction of this valve will be described elsewhere, under the head of Valves—so we need only just mention it here. Motion was given to the governor by means of a strap or chain, and pulleys, or else by bevel wheels, in either case driven from the crank-shaft of the engine. This form of governor is called the "pendulum" form. It will be noticed (in fig. 33) that the balls are suspended at points A, B, on either side of the spindle S; each arm, C, C, is connected by a link D to a block free to slide on the vertical spindle. The centres A, B, being fixed to the spindle and turning with it, as the balls fly outwards the slide E is raised, or if they fall there is a corresponding motion imparted to the slide. The effect of placing the centres A, B, a little distance from the axis or spindle is to render the governor less sensitive.

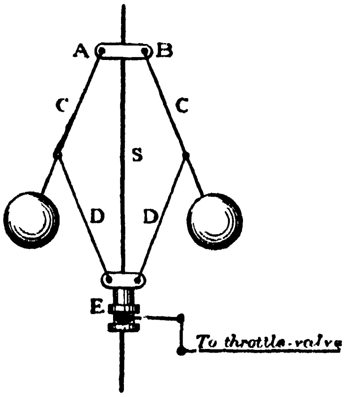


Fig. 33.

In Watt's governor the levers or arms were made in the form shown in fig. 34, being centred at C. In this sketch one arm is shown by full lines, and the other by dotted lines. The angle A C B always remained rigid, whilst motion was communicated to the slide E by means of the short lever A E, jointed at these two points. The result of this arrangement was that a considerable motion was given to the slide E by a slight variation of height in the weights.

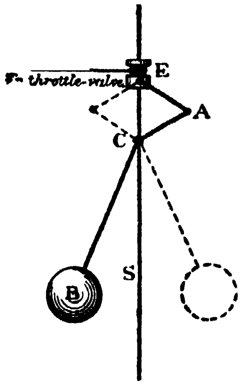


Fig. 34.

Another form of governor is that illustrated in fig. 35, and designed by Mr. Jeremiah Head, of Middlesbrough. In this design the points of suspension are on opposite sides of the central spindle; and its peculiarity lies in the fact that by properly adjusting the centres A, B, to the lengths of the arms it can be provided that the arc in which either ball moves shall be approximately an arc of a parabola.

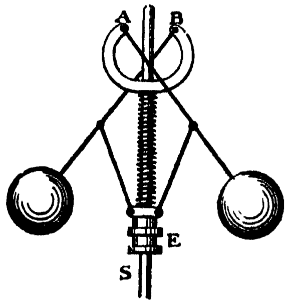


Fig. 35.

In a paper read by Mr. Head at a meeting of the Institution of Mechanical Engineers held in Middlesbrough, reference was made to a model of these three forms of governors—in which all were driven by the same crank and moved at the same rate. In starting them, the first to attain its extreme position was the crossed-arm governor of Mr. Head (fig. 35); then followed Watt's (fig. 34); and last of all, as being least sensitive, the common governor (fig. 33). Then, as the speed of rotation gradually decreased, the various governors collapsed in the reverse order—namely, the common governor first, then Watt's, and last of all the crossed-arm governor. In order that this last governor be not *too* sensitive, a light spiral spring is fixed, as shown, on the spindle, to prevent too sudden a movement of the arms, and retard them slightly in their ascent. The model here referred to may now be seen in the Science and Art Department of the South Kensington Museum. There are several other forms of governor used at the present time, and perhaps the form most unlike (in general appearance) the pendulum governor is that known as the Allen Governor. This consists essentially of a six-bladed fan attached to a spindle. On the same spindle is a case free to revolve, and filled about two-thirds with oil.

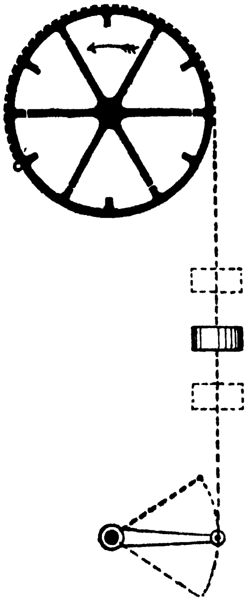


Fig. 36.

As the spindle is set in motion by the engine, so the fan is turned at a speed of about 350 to 400 revolutions per minute. There are also projecting ribs inside the casing, the edges of which just clear the edges of the revolving fan. The rotary motion, communicated to the oil in the cylindrical casing by the rapidity of the revolving fan, acts upon these projecting ribs, tending to drag the casing round with a force dependent upon the velocity of the fan. The tendency of the casing to rotate is resisted by a weight, the action of which is illustrated by the sketch, fig. 36, in which the weight is shown suspended by a chain coiled round the circumference of the cylinder or casing. The weight is adjusted in amount so as exactly to balance the tendency of the cylinder to rotate when the engine is running at its correct speed; but any increase of speed causes an increase in the rotary force that is communicated to the cylinder, and the resistance of the weight being consequently overcome, it is instantly drawn up; the throttle-valve lever being connected to the weight, the valve is closed by the rising of the weight, and further increase of speed in the engine is prevented. On the contrary, any diminution of speed in the engine reduces the rotary force so that the weight instantly falls, and opens the throttle-valve wider. Fig. 36 illustrates the principle of the governor, and gives a general idea of its working—the detail, however, differing a little in practice.

Valves.—Under this head it is intended only to describe the valves used to regulate the admission of steam to the ends of the cylinder, and not to include the various stop valves, safety valves, etc., etc. As may be seen by referring to drawings of early engines, circular valves are used, which rise and fall with every stroke of the engine. The form of valve and the method of using it, as adopted by Watt in his engines, for admitting steam to the cylinder is illustratedvery clearly in fig. 37. On raising or lowering the rod R, the valve was made to fall (close) or rise (open), motion being imparted to the valve by means of the segmental pinion engaging in the rack on the stem of the valve. This arrangement may have answered for slow-working engines, and in the days when coaching was considered a quick enough means of locomotion.

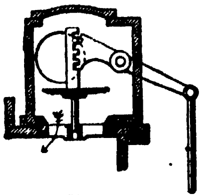


Fig. 37.

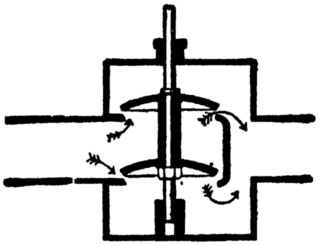


Fig. 38.

An improvement on this form of valve was that known as the double-beat valve. In the disc valve just described considerable power would be required to raise the valve if the pressure of steam were above it, or *vice versâ*; for if we consider that, say in a valve only 4 in. in diameter there is an area of about 12½ inches, and if the pressure of steam be, say 6 lb. per sq. inch, this will equal 75 lb. weight independent of the weight of the valve and rods. The double-beat valve was designed to overcome this difficulty. Its form and method of working will be easily understood from the accompanying sketch (fig. 38) and description.

THE GRAZIER AND CATTLE BREEDER AND FEEDER.

THE TECHNICAL POINTS CONNECTED WITH THE VARIETIES OR BREEDS OF CATTLE—THEIR BREEDING, REARING, FEEDING, AND GENERAL MANAGEMENT FOR THE PRODUCTION OF BUTCHERS' MEAT AND OF DAIRY PRODUCE.

CHAPTER XVII.

IN the analyses of foods which we have given in the preceding chapter, the reason why a third column is given to the oils and fatty matters, therefore, is not that they form a third division, but simply as a point of convenience as extending the last, and showing (what is often desired to be known specially) the percentage of oil, etc., in the various foods.

In prefacing those analyses we took occasion to refer to the difference of opinion between chemists and physiologists as to what are the nutritive parts of food. And it will have been noted by the intelligent reader that the chemist discards water, ash and woody fibre from the list of nutritive constituents. Glancing only at the first of these, it is, we confess, very difficult to understand the reason why water should, by the chemist, be considered as a non-nutritive element of food, It may, indeed, be difficult to define with precision what its effects are on the system in producing nutrition of some kind or another, as it may be difficult, and indeed is, to give their precise value to its effects, even if these be known. But that it is wholly valueless, as the chemist assumes, we cannot, either from scientific reasoning or from the analogies of ordinary life, bring our minds to believe. Judging from what we know, we should much rather be inclined to decide that water does not play a subsidiary or even a secondary part, or the part only of a single element; but that it is an essential, and that without it all the other elements of food would be wholly valueless. In other words, water is so important an element that it is the medium by which *alone* the other elements can be assimilated. It may not be *per se* (that is, by or in itself) a nutritious substance; but it is the vehicle, and the only vehicle, available in the constitution of man and of animals by which the other nutritious elements of food can be taken or conveyed, so to say, to the animal frame. If our readers remember what we have in a preceding chapter said on the subject of Manures, they will be able to trace an analogy bearing on the present case. A manurial substance or fertilising constituents applied to the soil would remain inert and exercise no influence upon the plants, unless water or moisture from the atmosphere acted upon it. Manurial constituents can only be assimilated by the plants when in a state of solution. And this will be readily understood when we consider the nature of plants and their roots and rootlets, with their almost endless ramifications of veins or tubes of infinite smallness, by which the fertilising juices, so to call them, are conveyed from the soil to every part. In like manner the reader will readily conceive how inert the solid parts of food would be if lying, and allowed to lie, in the stomach of an animal with the complete absence of water. Just as he can as readily conceive how the same food acted upon by water—in reality by the gastric juices, which, however, could not exist without water or moisture in the animal—being dissolved, would be readily assimilated and taken up by the countless vessels and tissues of the animal. As physiologists we are therefore justified in deciding that water is an essential element in all foods, without which all the other elements would remain in the system inactive. And this, the essential value of water, is quite apart from any consideration affecting its value or otherwise as a directly nutritive element in itself. It may be admitted that water *per se* is not a nutritive element, and yet this admission would not destroy the force of the statement that, notwithstanding, it was and is still essential that it should be present with all elements of food, otherwise these elements would not and cannot be assimilated by the animals.

But the physiologist, while claiming this high value for water as a part of food, and while so doing ready to admit that it may act only as a mechanical medium by which all the admittedly nutritive elements are conveyed to the tissues of the animal, goes very much further than this. For he claims for water a high value as an element of nutrition *per se.* And here again we confess to a feeling of surprise that chemists, with all the facts of experience before them, to say nothing of what from analogy may be considered to be facts—could have decided that in estimating the value of a food, the water, or moisture in a form which is designated as water, is to be discarded as an element of no value—as worthless. Water, on the contrary, is not only an element of some value, but it has a positively high value as a nutritive constituent of food. It might, indeed, be said with almost absolute scientific accuracy that it is the most nutritious of all foods. Certainly, taking them all, it possesses the highest value as a sustainer of life. For it is well known that a man will live longer who is supplied only with water—and nothing else, than another who is supplied with solid food, but deprived of water. Men with nothing but water have lived for long periods, who would have died long before had they been deprived of it; while the physical torture of a death arising from want of water is possibly the greatest man can suffer—greater far is it, certainly, than a death from hunger only.

While, physologically considered, it may be decided as a scientific fact or truth that water is in and by itself a highly nutritious element of food, there is still another point connected with it which causes considerations of the highest importance in the science of food and feeding. And this is when water or moisture is in direct relation to and connection with the plants themselves, which form the articles of food. And we would here claim from the chemist himself a due consideration of the points involved which are mainly chemical. From the analysis we have given of the various foods used in feeding cattle, our reader will have observed that water takes a prominent position. And this possibly to the surprise of some of them, who with such articles of food as wheat or oats may have associated, as is in the popular mind generally associated, the idea of extreme if not of absolute dryness. But while seed plants, as wheat and beans, have but a small percentage of water, and this varying very much according to season and condition, other farm food produce, such as root and leaf plants —turnips or cabbages—have a larger percentage of water, or what the chemist tells us and assumes to be water. More correctly speaking, this water is the "juice" of the plant. If the reader will turn to the analysis we have given in the last chapter of various foods, he will see that the root plants have all a high percentage of water, the lowest—the potato—having as much as 75 per cent.; the highest—the turnip —90½ nearly (90·43). Now, if this moisture or juices is or are to be discarded as of no value nutritively—being reckoned by the chemist as water, and therefore valueless—we are driven to the conclusion that all the nutrition of the root—say, for example, the turnip —lies in the small part which is solid, that is, in one-tenth only of the whole bulk. Turnips we know to be nutritious, to be liked, and to be readily assimilated by the farm stock. And of grass generally it may be said to be the natural and the best food for them; yet grass, like turnips, is mainly made up in bulk or weight of water, so that all that is nutritious in the estimation of the chemist lies in the small remaining bulk of material. Judging from the known effects of such foods as grasses and clovers, of roots, as mangolds, and of leaf plants as cabbage or rape, one would be inclined to conclude that there must be some nutrition in the moisture or "juices" of the plants.

But we should be inclined to go much further than this. We should claim the aid of the chemist himself in deciding, from a purely chemical point of view, whether the "juices" of a plant—as that of a turnip, for example—are to be considered as water only, that is in its ordinary condition, and therefore to have no value as a source of nutrition; or whether they are not something more than mere water. Apart altogether from what a close chemical investigation into and analysis of the "juice" of a plant would show, we can draw from analogy and facts as they exist in abundance around us the reasonable conclusion that the "juice" of a plant may in one sense be reckoned to be water only, and in another may be said to be water and something more. What that "something more" is, remains in the case of our farm foods to be discovered by chemists, for hitherto no investigations of a complete character have been made, or if made have not been published. But this we do not hesitate to say: that this "something more" than mere water which a plant juice possesses is a distinct constituent of the plant, and is that which distinguishes the juice of one plant from that of another. We say this all the more decidedly, for it is not to be denied that in flavour—to say nothing of other characteristics, such as colour, consistency and the like—the juices of plants vary. And this is certainly more characteristic of fruits, or perhaps is better known, as farm foods are not subject to the popular trial and liking which fruits receive. The great probability, we should be inclined to say, that the known and easily appreciated difference between the flavour of a pear and that of a peach lies first in the difference in that constituent, which is the "something more" than mere water, under which head the chemist would rank the juices. And the same holds true of the juices of a turnip and of a cabbage, of a Jerusalem artichoke or a carrot; this difference in flavour between each being the measure, or rather the indication, so to say, of the difference between the "something more" than mere water of the juices of those plants. Judging from scientific analogy, we should be quite safe in predicting that a strict chemical investigation into the juices of a plant used as food for farm stock would show that it was precisely in the character of the constituent which gave the difference in flavour—to say nothing of other characteristics—between it and the juice of another, that lay its nutritive value as a whole. Even from natural analogies we confess that we find it impossible to believe that the juices of all plants used as food are alike, and all to be claimed in water. The chemist, as evidenced by the analyses we have given, and by all other analyses we have examined (and their name is legion), would seem to decide that they were, and that all were valueless, inasmuch as we have seen he decides that water plays no part—even a very subsidiary one—in the processes of nutrition. We have seen that from a physiological point of view—and this we venture to maintain is the absolutely correct scientific, as it is the reasonable and natural one—the decision of the chemist that water is of no nutritive value is wrong. It is no less erroneous when it assumes that the juices of all plants to be considered and dealt with in the practice of feeding are the same. On the contrary, we believe that whenever the whole subject receives—as from its importance it is worthy to receive—a full scientific investigation, the result of this will follow the lines we have indicated, and that as the "juice" of each plant is already known by its flavour to be distinct from that of another, so will it yet be known by some characteristic constituent which will set it aside and mark it off as the peculiarly distinctive feature of the plant, and that which in all probability goes far to make the difference between the nutritive value of one plant and another. In the future, therefore, of the science of cattle feeding and food, we may reasonably predicate that in all estimates of the value of foods we shall find marked prominence given to the characteristic of the juices, or "water," as it is by analytical chemists called.

We do not wish it to be inferred that all chemists follow Liebig in the estimates they make of the value, or rather no value, of water as an element of nutrition, and in their decision that all the waters—juices—of plants are the same. But a large number of chemists—probably the majority—do follow Liebig in this. And we have always looked upon the views of this eminently great chemist as productive of practical evils in the art or science of feeding, as leading to misconceptions of a grave character tending to retard the spread of just views on the subject. We nevertheless felt surprise that this great *savant* should have decided the points we have been referring to as he did—doing so with a strange lack of that scientific acumen for which in all questions he was so remarkable. It certainly is, from a practical point of view, greatly to be regretted that his views should have been so widely accepted. So widely that nearly all—we might say, with truth, all—the published tables of the nutritive values of foods are based upon Liebig's assumption—for it was only this, and not a scientific truth based upon scientific facts—as to the worthlessness of water in a food; and that the waters—juices—of all plants are to be taken as precisely the same. On the other hand, there are distinguished men of science who take exception to Liebig's views on foods, and while accepting his theory generally as correct, and admitting the singular accuracy of his investigations and analyses, and the clearness and general soundness of his deductions, set their faces firmly against some of his views—and markedly on this of water. And it is to be hoped that their expositions of those views will yet be as widely disseminated amongst the reading portions of the farming community as the tables generally published. Amongst the eminent scientists of our day, who hold more reasonable and more scientifically accurate views—based upon an eminent knowledge of science in all its departments—must be named Dr. Voelcker, who, as Consulting Chemist to the Royal Agricultural Society of England, was, during many years of his useful life, assuredly at the head of agricultural science. Dr. Voelcker, in more than one able paper, characterised as much by the clearness of their exposition as they are distinguished by the soundness of their scientific opinions—drew marked attention to the fact that the value of foods or farm stock cannot be studied solely from the point of view which chemistry alone affords. He showed that the views and deductions of physiology must also be considered.

And that this view is pre-eminently the sound and safe one for the practical feeder, as it is a right point of view for the man of science, is to our mind beyond a doubt. For in the feeding of animals we have of necessity to deal with organisations in which are present, and ever acting, all the phenomena of life; and it is here where creep in the errors which the purely chemical view of the subject give. As we have before said—and from the practical consideration which it carries it is worthy of repetition—the deductions of the laboratory, with all its fixed and dead appliances, must be in practice greatly modified when life with all its varied and ever-varying phenomena are dealt with. Whatever may be assumed—and in the practice of the laboratory it is too often assumed—the experiments of the crucible and the test tubes do not give all the results nor afford all the indications of the trials of foods given practically to the animal. What goes on in the test tube can be seen or known with definite precision; what goes on in the animal's body cannot be seen, and is not by any means always known. We can only conjecture, but it is important that we conjecture reasonably—that is, base our opinions upon what we do know, not upon what we conceive we know.

There are, however, certain other points connected with the chemistry of food yet to be noticed, and in which the science of physiology comes in to give us information of grave importance to the practical feeder of farm stock. In referring to the analyses of foods which we have given, the reader will perceive that amongst the elements of non-nutrition the woody fibre of plants is classed. It is this which generally contributes, along with water, to the bulk or size of the plants. In the case of cattle, fattening oxen and dairy cows, the formation of the stomach, with its large capacity, shows that bulk must, or ought to be, a characteristic of the food given to them. The stomach can only fulfil its functions perfectly when its surface with all its vessels acts upon the food; so that if this be given in small portions, or in a highly concentrated form, digestion is not properly developed. Hence, when very rich food, and which therefore occupies less space, is given to an ox or a dairy cow, other and less rich food must be given along with it: straw is generally used for this purpose.

THE CARPENTER AND HIS TECHNICAL WORK.

ITS ORIGIN AND EARLY WORK—THE PRINCIPLES AND DETAILS OF ITS PRACTICE.

CHAPTER XIII.

CONTINUING our remarks on roofing joints, junction of king and queen posts with tie-beam, we give in Fig. 6, Plate LXI., the assemblage of timber at head of queen post *a a* in diagram (elevation) A; *b b* end of principal rafter tenoned into queen post, in the side of which, opposite to principal, is the straining beam; *c* common rafter, as at *d*, *e* purlin. In diagram B another method of joining end of common rafter to head of queen post is shown.

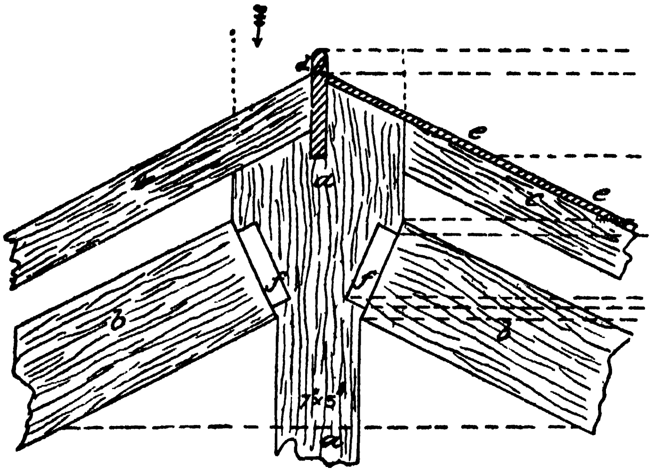


Fig. 65.

In the joints used in framing which in preceding chapters we have illustrated and described, the two pieces or members which go to make up the joint as a complete arrangement, each piece has been supposed to be of the proper dimensions—in length, breadth, and thickness. It frequently happens that while the dimensions in section—that is, in depth or thickness and breadth—can be easily enough obtained, the length is deficient; and it is difficult, in many cases impossible, to procure a beam having the requisite cross-section—breadth and depth—with a length in one piece sufficient for the work to be done, or for the office the beam has to fulfil. Hence methods in practical carpentry have to be resorted to to make a long beam out of two or more short ones.

It is to the devices employed in doing this essential work that we now propose to direct the attention of the reader. If he will refer to the various joints we have in preceding chapters given, he will see several forms which are obviously devices for lengthening short timbers—that is, for making a piece practically one out of two separate pieces, either equal or unequal in length. All the joints used in connecting two pieces both of which when put together lie in the same line, either horizontal or vertical, are of this kind. But there is this distinction between those joints we have already given and those we are now about to present to the notice of the reader, namely, that they are usually adopted for pieces of small scantling comparatively, whereas the devices now to be illustrated are employed for pieces of large section, and which are commonly called beams. We have given a wide variety of joints adapted for the junction of pieces having different relations to each other; but those we are now about to give are used only where pieces are to be joined in the direction of their length.

Beams are lengthened by one of two methods — "fishing" and "scarfing." The simplest method of "fishing" a beam is illustrated in fig. 66; in this the two beams are placed together so that a short part of the length of each rests on the face of the other piece, as at *a a*, *b b*, and when so placed secured together by means of a rope, as at *c c*. It is obvious that if the two pieces are round in section the joint will be anything but a firm or secure one, as each piece has a tendency to ride or roll upon the other. A much more secure joint in this, the simplest and rudest way of lengthening a beam, will be had when the pieces are square in section, as *d d*, *e e*; and the junction may be made more permanently secure by binding or tying them together by iron straps, as at *f f*.

But, however secure may be the joint effected by either one or other of those two methods of fishing,—and they are often adopted in rough work, as in bricklayers' and builders' scaffolding—they obviously give a very inconvenient form of joint, from the projections they offer,—these quite interrupt the continuity of the piece considered as a single member, by the "steps" formed in opposite sides, the upper and lower, of the beam. Another method of fishing a beam is therefore usual.

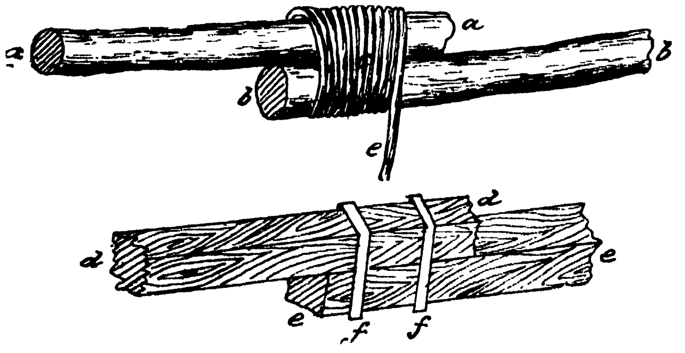


Fig. 66.

This gives a perfectly flush surface to the united pieces throughout the whole length of the member, considered as a whole. This method is often called "splicing," more especially by seamen, with whom it is a favourite method of gaining one strong piece or spar of timber out of two short or broken pieces of unequal length. The term "splicing" no doubt originated with them. As to the other term, "fishing," which is applied to the method—although this also appears to have a maritime origin—it is apparently a term which is a corruption of the French word *afficher*, to fix or place and secure one body in contact with the other. Fig. 12, p. 14, vol. i., and fig. 67 illustrate the method of fishing timber known as splicing, and which gives a piece as a whole actually more strength than the original piece, supposing that the new piece is to be formed out of the two pieces of a broken spar, for example. If *a* and *b*, fig. 12, represent the two halves or pieces into which the spar has been broken, each half or part is cut up longitudinally in the direction of the dotted line—thus giving four pieces, two short, out of the piece *a*, and two of them long, as got out of the piece *b*. The pieces are then placed as in the diagram in fig. 67; so as to "break joint," the joint *c* of the junction of the short piece *c g*, and the long one, *h h*, butting against the solid part of the lower long piece *e e*. In like manner the joint of the short piece *d b*, and long *e e*, butts against the solid part of the upper longer piece *h h*. Such is the effect of this simple, yet thoroughly scientific—in a constructive sense of the term—method of jointing the piece of a broken part, that the spliced or half arrangement, as in the lower design of fig. 66, is actually stronger than the original unbroken piece. In ship carpentry the pieces thus "rigged out" are held together by strong tarred rope; but in carpentry, as applied to general work, bolts and nuts, or strips of hoop iron bond or rings of wrought iron, are slipped in while hot, and shrunk by becoming cool.

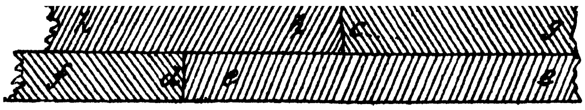


Fig. 67.

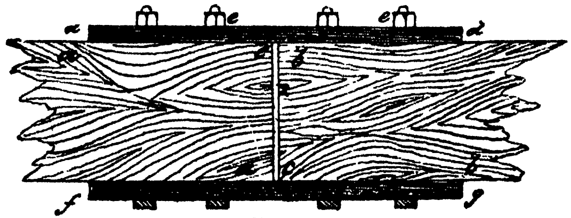


Fig. 68.

The methods used for joining timber by that known as "scarfing"—are pretty numerous: fig. 9, p. 13, vol. i., illustrates the "scarfing" of two pieces *a* and *b*, the end of each piece being cut longitudinally in the direction of the centre of the two pieces; so that when laid together they are "flush" with the general surface. The joint is called generally a "half-lap" one. The two pieces are secured together by iron bolts and nuts, as at *c, c, c*; *d d, c'd' c'* in the lower diagram showing the bolt holes in the lower piece *b'b'*, corresponding ones being bored in the upper piece *a'a'*. The term "fishing joint" is also applied to the method of joining two timbers as illustrated in fig. 68—the ends being simply squeezed up, and there being no lapping or laying of one piece or part of a piece upon another, which is the distinguishing feature of all "scarf" joints. The pieces butt at their ends with even joint, as *c*, and the two are held together by "fishing plates"—one, as *d d*, at the upper side, the other, as *f g*, in the lower side of the two beams. The "fishing plates" are sometimes partly sunk into the beams, as shown at *a* in fig. 69—or formed at end, as at *g*, and that to the right are part sections. In place of bolts and nuts, as at *c c*, fig. 70, hoops of wrought iron as in cross section at *e' f'*, fig. 69, and part side elevation at *e e, f f*, shrunk on shows the complete fishing plate. Iron fishing plates are the best, and being thin, are often sunk into the faces of the two beams, so that the surfaces are flat, the only projecting parts being the bolt heads and the nuts.

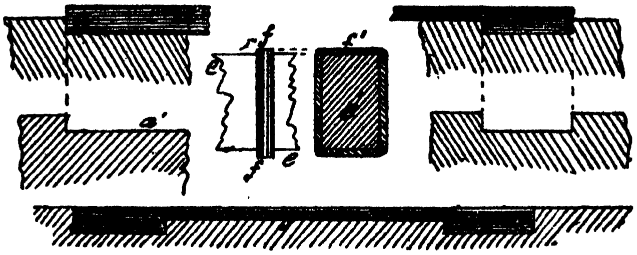


Fig. 69.

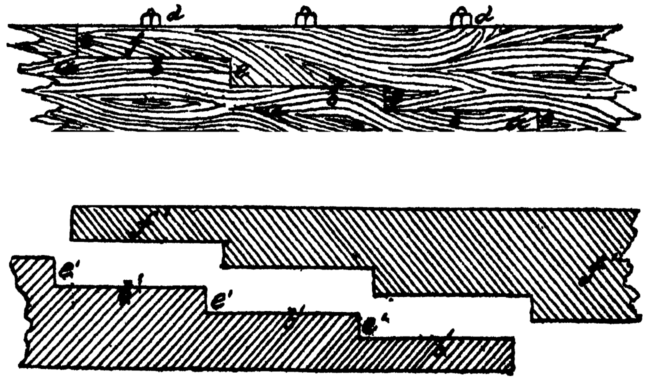


Fig. 70.

THE STONE MASON AS A TECHNICAL WORKER.

THE PRINCIPLES AND PRACTICE OF, AND THE MATERIALS HE EMPLOYS IN, HIS WORK.

CHAPTER XII.

We have said at end of last chapter that projecting parts in moulded work give play of light and shade. And this is the characteristic of a well-designed elevation, and distinguishes it from one having little or no projection, which is bald and tame, however lavish and ornate the ornament with which the parts individually are treated. Fig. 72 illustrates a "cornice block," *a a*, moulded in face, built into the wall *d d*. Part of the design of the "cornice" is in this case formed by the front part, *b*, of the "gutter" wood-work *e e f*, *h h* being the rafters resting on the "wall plate," *g i* the "tilting piece" to raise up the first of slates, *j j*. The "ceiling joist" in the interior of the wall is at *l l*, *k* the wood-brick, *m m* the "cornice" in the interior of the room—scale same as for fig. 71. Fig. 73 is section and fig. 74 part elevation of the "cornice" of a "bay" window—in the "Domestic Gothic" style—drawn to a scale of six inches to the foot, or half size. Fig. 75 is section, and fig. 76 part elevation, of another cornice—scale same as last two figures.

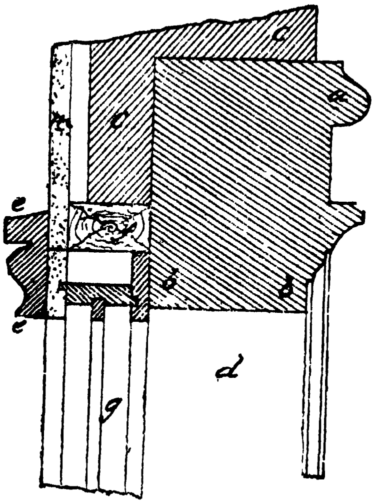


Fig. 71.

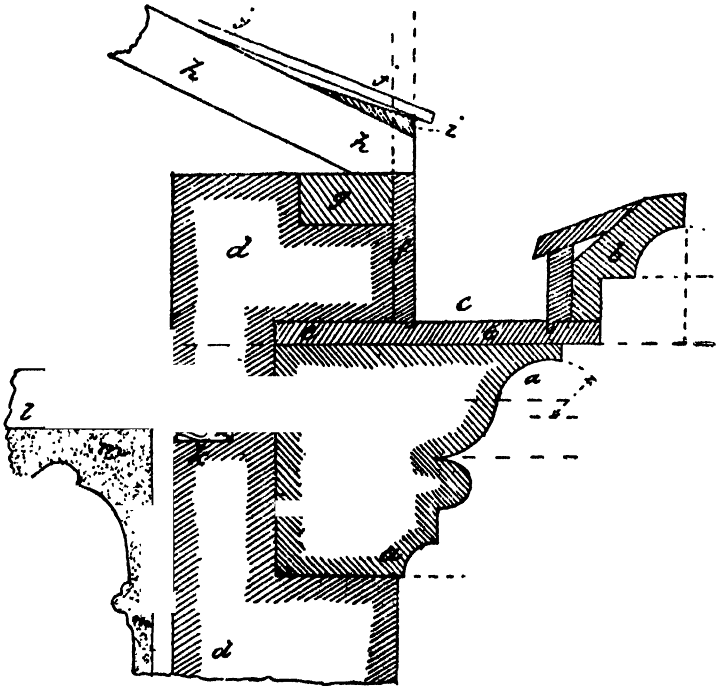


Fig. 72.

Chimney Cap and Window Head Mouldings.

Fig. 77 is section of mouldings at the upper part or "cap" of a chimney in the "Domestic Gothic" style —drawn to a scale of two inches to the foot, or one-sixth full size—of which fig. 78 is half of the elevation, and fig. 79 of the base of same, these two being drawn to a scale of one inch to the foot, or one-twelfth full size. Fig. 80 shows the mouldings for the cap of another chimney—scale two inches to the foot. Fig. 81 is section of window head, and fig. 82 part elevation of the same.

Arch Mouldings.

The arches of "Domestic Gothic" work, as the arched heads of doorways, are all more or less moulded in the inside lines; the mouldings run up each side of the door opening, and are continued round the inner concave, or "soffit" of the arch. A section taken through a line, say at right angles to the length of the side of opening, at any point of the arch in a line vertical to the centre from which the curve of the arch is struck or described, will give the "contour" or outline of the mouldings. Thus, fig. 83 represents the outline of mouldings as shown in section of the mouldings of an arched doorway. The drawing shows only one-half of the mouldings on one side of the centre line dotted, the other half being simply a repeat of that shown. The lower part is that which is seen nearest the spectator in looking up to the arch of the doorway overhead; the mouldings gradually widening out from this central point to the sides. In looking at the sides, or jambs, of the arched doorway, the mouldings are seen as shown in the elevation in fig. 84. Figs. 83 and 84 are drawn to a scale of one-half full size.

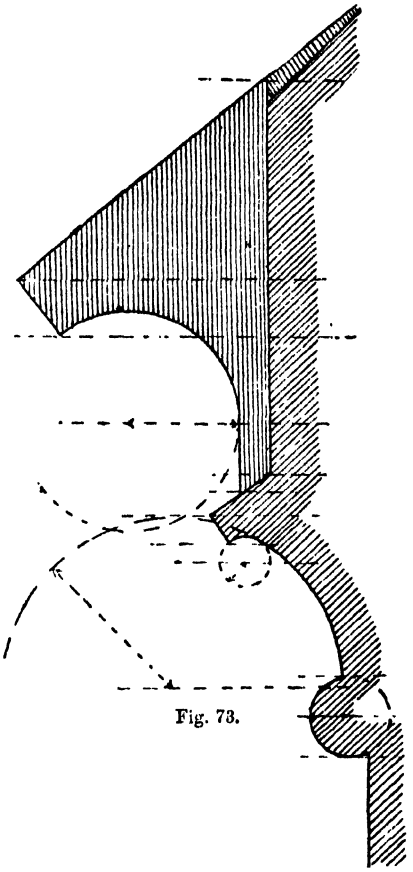


Fig. 73.

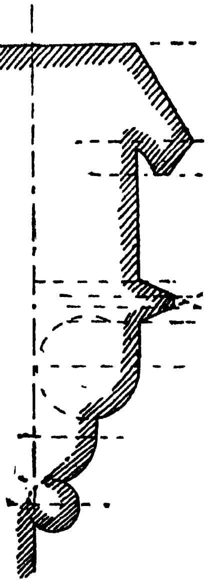


Fig. 77.

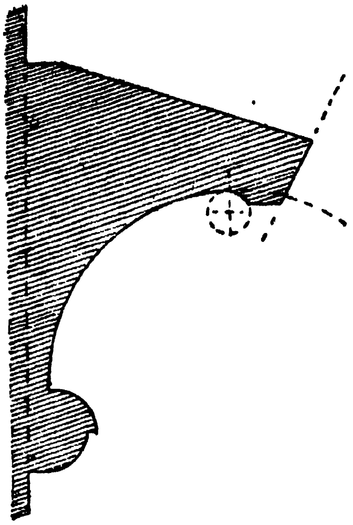


Fig. 75.

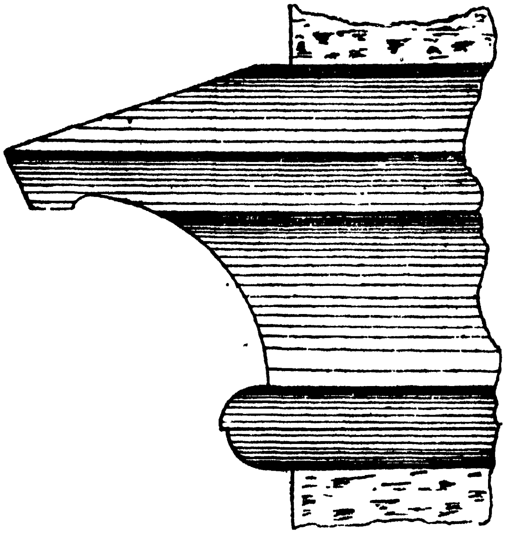


Fig. 76.

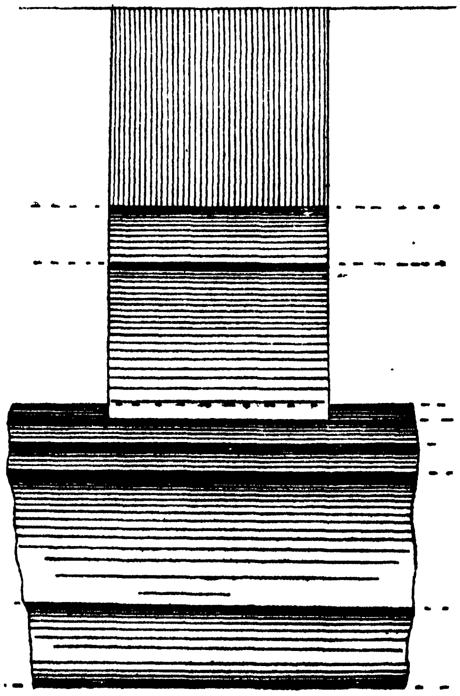
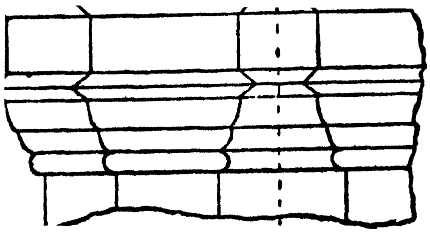


Fig. 74.



THE BRICKLAYER OR BRICKSETTER.

PRINCIPLES AND PRACTICAL DETAILS OF HIS WORK.

CHAPTER IX.

THE "reveal" (described at end of last chapter, and represented in fig. 2, Plate X.) in ordinary work is only made half a brick thick or deep, from *i* to *j*; but in superior work it is much deeper. The door or window frame, as *k*, goes into the part *l m*. In another class of "reveal" work the inner face at the point *h* is "splayed" or bevelled off, as at *n*, and the reveal is then called a "splayed reveal" or "splayed jamb," a "square jamb" or "square reveal," being as at *o p q*. In fig. 9 we give in diagram A the first course of part of a brick wall—one brick thick—showing a square reveal, and in B the second course of same. All the succeeding courses, to whatever height the wall may be carried, are just repetitions of these two first courses. In diagram A, *a* is the offset or reveal, which is square, *b b* is a three-quarter brick, and *c* a "bat" (see preceding paragraph); *d d* the course made up of "headers." In diagram B the course is made up of "stretchers," *a'* being the "square reveal" corresponding to *a*, *f* being a half-brick put in to form the shoulder of the "reveal." The drawing in fig. 9 shows the reveal, as *a' a*, as a crossed or hatched solid: this should be a dotted space, as in next fig., not shaded. In fig. 10 we give in A first course of a "splayed reveal" for a wall a brick and a half in thickness, in which the reveal is formed by a half-brick, a splayed closer, and a splayed bat. In the second course at foot of drawing the reveal is formed by a half-closer and a splayed or rubbed half-brick. The application of a square reveal to a wall in which recesses are formed in its face at intervals, is shown in fig. 11 at A, in which *a a* is the wall, *c b c* the recess, with reveal at *c*, *e d* the centre line of recess, corresponding to *f g* in B, which is the opposite half of second course, a splayed brick being used at *d'*, and a half-closer at *e'*.

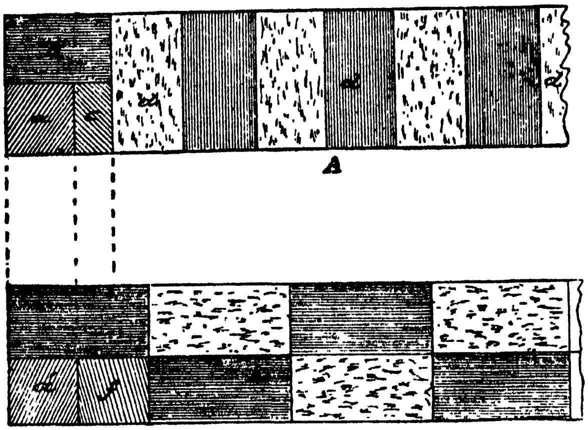


Fig. 9.

Special Methods of adding to or securing the "Bond" of the "Bricks."—Timber.—Bonding—Chain Bond.—Wood Bricks.

"Bond" in brickwork, in addition to being obtained by one disposition of the bricks in relation to each other, as we have explained generally in the illustration already given, and which will be more fully and specially illustrated in giving, as we shall presently do, the various thicknesses of walls, both in solid and in hollow brickwork, is also secured, or at least aided, by the use of what is called "bond timber" and "bond hoop iron." Bonding with timber is simply the placing of narrow battens or pieces of wood of greater or less length on the upper face of the
and building or covering this in with
courses. The wood may either be wholly
the interior of, or by the brickwork; or it may be exposed at one side of the wall; this is generally the interior side, and this is done in order that the wood

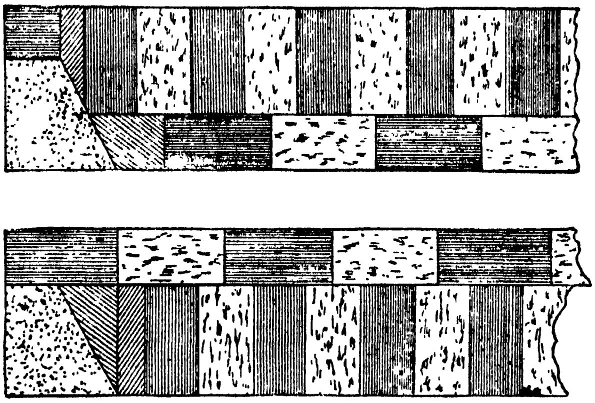


Fig. 10.

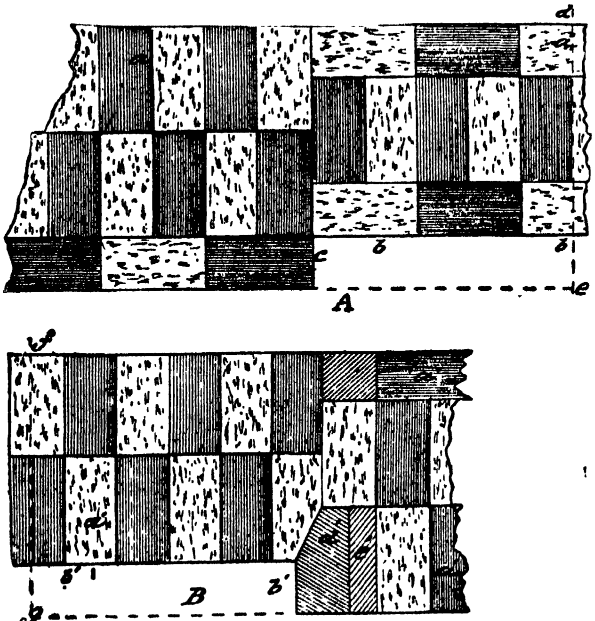


Fig. 11.

bond may be made available to nail or secure to the wall the interior fixings of joinery work, such as skirting boards, dados, or the like. If the bond timber is carried round the room, it is called "chain-bonding," and there are usually several tiers, so to call them, of this—such as one tier or chain at a height from the floor sufficiently high to admit of the skirting board being secured to it (this being called the "skirting bond"). If a deep dado be used in place of the shallow skirting board, another chain of bond is placed above, to which the upper part of the dado is secured. Another chain is placed near the ceiling, and is called the "wall or plate bond."

In fig. 12, *a a* shows a chain bonding of timber in front view or in elevation, *a*, as laid or let into the wall *b b*. The surface of *a a* as generally flush or coincident with the surface of the wall as shown at cross section at *c*, *d d* being face of wall.

To fix or secure the various parts of door and window linings, it is necessary to have pieces of wood built into the walls, in order that these shall bond with the ordinary bricks; they are made of the same dimensions, and are called "wood bricks"; they are usually inserted in the "jambs" or "reveals" of the window or door openings, as at *e*, fig. 12, *f* being front or side view. They do not go through the whole thickness of the wall, but stop short of the exterior surface of it, as at *g*.

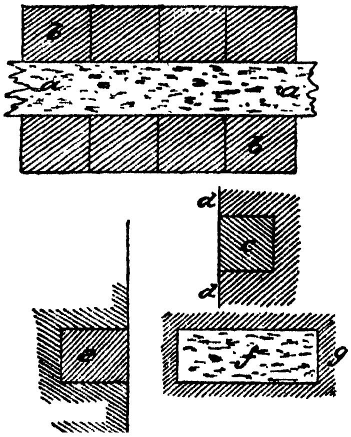


Fig. 12.

"Hoop Iron" Bonding.

Timber being very apt to decay, and thus to produce unequal settlement in the wall into which they may be built, it is now in first-class work discarded in the case of chain bond. Wood bricks still require to be used in order to nail the wood or joinery linings to. But iron in the form of what is known in the trade as "hoop iron" is used in place of wood bond. This iron is in narrow strips, about an inch in breadth, and is generally coated with a painting of tar before it is built into the wall, this being done to secure immunity from rust. The hoop iron is usually laid in the centre of the wall, as at *a a*, fig. 13. In order to insure a still more perfect bond or union between the surface of the hoop iron and the brickwork and mortar, holes are sometimes punched at intervals along the surface of the iron, as at *b* or *c*, fig. 13. These are all punched from the upper or the same side, and the rough protuberances, the result of the operation, as *d*, are left or allowed to remain on the under side. These protuberances serve as keys or holdfasts, taking into the mortar or the joints of the brickwork. A very excellent kind of hoop iron bond is that known as Tyermann's, and is now largely used. In this, diagonal cuts, as at *e e'*, fig. 13, are made on each side or edge of the hoop iron; and as these are made, they are lifted up or raised a little, as at *f f*; forming catches corresponding to the protuberances *d d*, which take hold of the mortar and bricks, and thus secure a very firm bond.

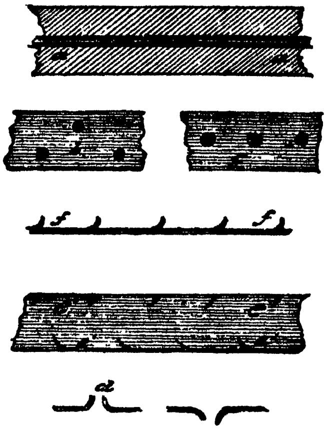


Fig. 13.

Formation of Walls of Different Thicknesses—One-Brick Wall—Brick-and-a-Half Wall—Two-Brick Wall, etc., etc.

Having now gone into what may be called the elementary details of brickwork, we are now prepared to give illustrations of "Bond" as practically carried out in the construction of walls executed of different thicknesses and of different classes of bond. Of these we shall take up the "Flemish bond" first, of the principle of which we have given a diagram in fig. 2 *ante*.

Brick walls for exterior work usually range in thickness from one up to three bricks; a one-brick wall being generally known or classed as "nine-inch work"; and this is very extensively adopted for the walls of cottages and inferior houses, although it is in this damp climate of ours too thin for dwelling-houses, unless the bricks are so disposed as to form a hollow, or cavity, which increases the thickness to "eleven inches," and this without involving the expenditure of additional bricks. Walls of a brick and a half thick are usually termed "fourteen-inch work."

THE JOINER.

The General Principles and the Details of his Work.

CHAPTER XI.

The section of part *fg* looking at its end, in direction of arrow 2, is shown at *l m n*; the section of a moulding is in this at *e′*. In lower diagram to the right is given a view of under side of rail *fg*. In fig. 4, Plate XXV., *a a* is front view of part of style with moulding worked on edge, at *b b*; part of rail is at *c′ c′ d*. The angular face of part cut out in style *ef*, *fg* corresponds with angular end *h i j* of rail, but a tenon *i l k* is left on, or is inserted in end of piece *c′ c′ d*. The end view of the style *a a*, looking at it in the direction opposite to that of the arrow 3, is shown in the middle diagram to the right with corresponding letters accented, showing corresponding parts. The line *i″ i″* corresponds to the line at point in rail *c′ c′ d d*. The plan of under side of rail *c′ c′ d* is shown in diagram immediately below *k′*, *l′* being edge view of tenon *k l*. The finished joint is shown at *o o*, *p p*; the diagram below to the left being cross section to the line 1 2. Enlarged elevation *q*, and section *r* of moulding *b b*, or *b″* is given in the two diagrams to the right at bottom of drawing. Another method of forming the junction is shown in the middle diagram at the foot of fig. 4, Plate XXV., the shaded part showing form of tenon with the ends of moulding united.

A four-panelled door.

In fig. 1, Plate IV, we give a drawing—to a scale of ⅛, or 1½ inch to the foot—of a four-panelled interior or room door; showing all the leading parts of the framework, with the exception of top rail, which is usually about half the breadth or depth of the middle or lock rail, marked *b b* in the drawing. The panels are not shown, but the dimensions of the spaces they occupy are given. The panels are plain "square," the only ornamention in this example being a "stop chamfer" worked on the margin of styles and rails, as shown at *g g* and *h h*. In the drawing *a a* is the "bottom rail," *b b* the middle, or usually "lock rail," as it carries the "mortice lock," the handle of which is shown at *j*. The "key hole" is covered by a movable part, hung or jointed at upper end, called the "escutcheon," or more frequently in technical talk the "scutcheon" or "skutcheon," shown at *k*. The styles are at *c c*, *e e*, the style *c c* termed the "lock style," being that in which the lock is mortised. The style *e e* is called the "hanging style," being that on which the door is "hinged" or "hung" to the door casing. The vertical pieces, or "muntins," which divide the panels from each other, placing them in pairs on each side of the door, are shown at *d d*. The door framing thus constructed is surrounded on both sides and at top by the architraves *f f f*.

Architrave of a Four-Panelled Door.

The section of architrave in relation to the door casing or cheek is shown in upper diagram to the left in fig. 2, Plate XXV.; *a a* being part of the door casing; *b b*, the section of architrave, of which part elevation is shown at *c c*, 1, 2, 3, and 4 showing similar parts in section correspondingly lettered. The edge view of the "lock style," as *e e* in fig. 1 preceding, is shown at *d d*; *e e* shows the brass plate let into the edge and secured by screw nails as shown. This is part of the lock furniture of the door, *f* indicating position and section of the shooting or locking bolt of the lock, which passes into the aperture of a brass plate secured to the inner side or edge of the door casing. The bolt, which secures the door, being closed—not locked—*f* being the locking bolt, is shown at *g*, this being worked by the handle *j* (see fig. 1, same Plate), of the lock. The part of the lock furniture attached to the door-casing opposite to the edge, as *d d d*, of the door style, is shown in the lower diagram to the right. The part 3 3 in this corresponds to the face of the recessed or rebated part *p* in drawing above, cut in the face of the door casing *n n n*; the door passing into and resting against the face of recess or rebate *p*. In the upper diagram to the right, *o o o* is the outer architrave secured to the door casing *n n n*, *r* part of the inner architrave. The part of the lock furniture secured to the door casing is shown at *t t*; it is a brass plate let into the face *q*, or 3 3 of recess or rebate *p*. The aperture in this into which the bolt *f* of the lock passes is shown at *v*; that into which the bolt moved by the handle *j* passes, is at *u*; a spring *w*, cast on to the plate *t t*, being shown at *w*. A small projecting part as *w′*, to make the opening and closing of the door more easy. The two diagrams to the left at lower part or drawing show the elevation *k l m*, the chamfered part of framing with section at *k′ k′*.

Sash Windows

are of various kinds, but two are generally adopted now—the "sash" window, and the "French" or "casement." Sash windows are divided into two parts, called the upper, as *a a*, and lower sash, as *b b*, fig. 1, Plate LXXXIII., or technically "sheets," and are either "fixed," "single hung," or "double hung." In the "fixed" sash, neither upper nor lower sash is capable of being moved vertically up or down, or opened or shut. In the "single hung" one sash or sheet—almost universally the lower—is capable of being lifted up; in the "double hung" the upper sheet, as *a a*, is capable of being lowered, the lower, *b b*, of being lifted up. To enable this to be done, the sheets are suspended by ropes or "cords" passing over pulleys, the "cords" being furnished at end with counterbalance weights called "sash weights,"—all these are connected, as will presently be illustrated. The old-fashioned division of the sheets of a sash window into six small rectangular panes of glass is, in consequence of the improvement in the manufacture of this material, almost wholly superseded by large "panes" of "plate," or of an inferior quality of plate, yet strong and clear, known as "British plate glass." These forms of glass enable the sheets to be made of one piece only if desired; but the arrangement as shown in fig. 1, Plate LXXXIII., is the most generally adopted, where a central division, termed a meeting, or middle bar, as *h h*, divides the window into two, each sheet is further divided into two by a suture bar, termed an "astragal," or "sash bar," and in large windows, of considerable section, a "mullion," as *c c*, fig. 1. A "French or casement window" is one in which the two sheets, *a* and *b*, fig. 2, diagram to the left, Plate CLXXX., are hung so as to open vertically, precisely as a folding door is hung, and is opened or closed. The sheets, however, in place of stretching from top to bottom of "casing," or of the opening or "void" of the window, stop short of the top, and close against a cross-bar stretching across the opening or void, as in fig. 2, to the right, Plate CLXXX.; the space above this being a fixed sheet, divided into two "panes" by a central vertical astragal, or formed of one pane only. To keep the vertical joint of the two lower sheets water-tight when closed, the styles are rebated, and in some cases the rebate is provided with a groove with rounded bottom, the other rebate being rounded to same curve, this going into the groove when the window is closed. Fig. 1, Plate CLXXX., is large-scale drawing of skirting-board in fig. 1, *d d*, Plate LXXXIII.

In fig. 1, Plate LXXXIII., an inside elevation—from interior of room—of a double-hung sash window is shown; in fig. 2, Plate LII., part horizontal section and plan of one side of window, taken on the line 1 2 in fig. 1, Plate LXXXIII. Fig. 4, Plate LXXXIII., is part vertical section at bottom of fig. 1, same plate, the scale to which this is drawn being one inch and a half to the foot. In fig. 1, Plate LXXXIII., *d d* is floor line, *e e* "skirting board," *e′ e′* wall space between this and "window sill" *f f*, *g g* the architrave, surrounding the opening on three sides, *h h* the middle bar, or properly speaking the upper cross-bar of lower sash frame. The sheets or sashes are formed of bars tenoned into one another in one or other of various ways.

In vertical section, fig. 4, Plate LXXXIII., and in horizontal section in fig. 2, Plate LII., the letters of reference are the same, indicate the same parts; the other parts, not seen in either one or the other, are as follows: beginning with fig. 2, Plate LII., the sash weights, *i i*, are enclosed in a species of box extending from top to bottom of window opening, of which box, so to call it, *j j* is the "outside lining," *k k* the "back lining," *l* the "inside lining," *m m* the "pulley style," *o* the "parting slip," and *p* the "parting bead." In the frame of the upper sash *a a*, fig. 1, Plate LXXXIII., of which *a* is the side bar, *q*, fig. 2, Plate LII., is the pane of glass, and in frame of lower sash of which *b′* is the side bar, *r* is the pane. In fig. 4, Plate LXXXIII., the same letters of reference as in fig. 2, Plate LII. indicate the same parts; but *s s* is the stone window sill, end *t* of which is outside, *u u* wall, *v v* "reveal" of window opening. Fig. 4, Plate CLXXX., is plan of top of lower sash *b b*; in elevation, fig 1, Plate LXXXIII., *a a* is the top of upper bar of sash frame, *b b* side bars, *c c* the finger "bowls," or lifting hooks (finger "rings" are sometimes used), by which the sash is lifted. In fig. 4, Plate LXXXIII., *x* is position of window-blind rack and pulley, the window-blind roller studs being placed vertically above *x*. In fig. 2, Plate LII., the cord to suspend the sash weight *i* is placed in a groove—at black dot—in the side bar *b b*, as at *y o*. Fig. 5, Plate LII., is elevation to same scale as fig. 4, Plate LXXXIII. is drawn—1½ in. = 1 ft.—of the lower corner in fig. 1, Plate LXXXIII.

In fig. 5, Plate CLXXX., diagram A, is given part elevation of the sash bar *a a*, and top elevation, *b*, of the sash frame, the inner edges of which, as at *c c*, being moulded to correspond with part *a* of astragal in diagram B, which is a cross section in line 3 4 in fig. 1, Plate LXXXIII., diagram C being part of front elevation, and diagram D side elevation of same; in diagram B, *b b* is the glass. In fig. 1, Plate LII., a method of securing skirting-board, *e e*, is shown; this is tenoned into floor joist at *h*, and the skirting-board is secured to "wood grounds" or wood bricks at *a′ a′*, *c′* being the plaster, the lower edge of which passes into a groove, not shown in the drawing, in the upper edge, of ground, *a′*.

French or Casement Window.

In fig. 1, Plate CXVI., we give part horizontal section in centre of the casement or French window, taken on the line 2 3 in the diagram to the right of fig. 2, Plate CLXXX., and in fig. 3, diagram B Plate LII., a part vertical section, taken on the line 1 2, fig. 1, Plate CXVI. The vertical side bars of this casement window, fig. 2, Plate CLXXX., diagram to the right, are seen at *a b* in fig. 1, Plate CXVI., and are rebated, as at *c*, to make a water-tight joint from top to bottom of window. To prevent the water from being blown into the horizontal joint, where the bar *i*, fig. 3, Plate LII., is over the sill *h h*, a "weather board," *d*, is fixed to the sash, this being throated at the lower side—that is, grooved horizontally from end t[illegible] end to prevent the drip from passing from foot of board to the joint between the sash bars.

THE IRON MAKER.

THE DETAILS OF HIS WORK AND THE PRINCIPLES OF ITS PROCESSES.

CHAPTER V.

At the end of last chapter we stated that at one period in the history of the iron trade, when charcoal was used in the manufacture, the timber districts were actually its seats. And such districts were almost wholly confined to counties south of London—Sussex, Surrey, Kent—Gloucestershire, and part of Worcestershire—and of these Sussex was the chief. Now the localities of the trade are wholly west and north of the metropolis, and of these quarters the north has by far the pre-eminence. The inciting cause of this remarkable change of *locale* was, as we have shown, the introduction of the Dudley coal-smelting process. Hence we find the busy seats of the iron trade in those parts of the country in which coal and iron ores lie in that close proximity which we have shown and believe to have been providentially designed—not the mere outcomes of chance, as some say, unless, keeping to this word, we say, with one of the grandest of our poets, that " that *chance* the good God did guide"—to be one of the primary sources of our powers for the production of materials so essential to the promotion of the welfare and to the progress of civilisation of the peoples of the world. Beginning with the counties west of England, the Principality of Wales, going on to the north of England, and ending with Scotland, we find the *locale* of what are really the iron and coal districts of the kingdom to be as follows: Gloucestershire and Shropshire, North and South Wales, Warwickshire, Northumberland, Durham and Cleveland Districts, Yorkshire, Lincolnshire, Cumberland, and Scotland. Some of these districts are old, as what is called pre-eminently the "Black Country," stretching between Wolverhampton and Birmingham, Staffordshire, Gloucestershire, certain parts of Wales, Yorkshire, and Derbyshire; and some are comparatively new, having been opened up but of recent years, such as the Cleveland District, in the north-east of Yorkshire, of which Middlesborough may be taken as the seat or capital,—the ores being very abundant, but of quality fitted only for irons of the inferior classes when made on the old system; but which offer quite a new prospect when worked on the "basic" process of Bessemer steel making (see "The Steel Maker"). Under this class of new districts comes secondly the district of Ulverstone, of which Barrow may be accepted as the seat. The ore in this district is the celebrated red hæmatite. In Scotland, Lanarkshire and Ayrshire are the chief localities—indeed, Lanarkshire may practically be said to be the locality of the Scottish iron trade, of which Glasgow is the capital. For long Scotland was dependent—almost wholly dependent—for its supply of cast iron upon the North American colonies. The first attempt to introduce systematic iron working into Scotland was a successful one, for it supplied for a long period nearly, if not wholly, all Scotland with cast-iron goods. It was made by Dr. Roebuck, of Sheffield—a name which will always be associated with that of the celebrated Watt—who with other gentlemen established a joint stock company which opened about 1760 works soon and widely known as the "Carron Iron Works," taking the name from that of a small river in the county of Stirling, and not a great distance from Falkirk. The ore principally used there was obtained from Lancashire and Cumberland, supplemented by such limited supplies as were then and for a long time obtained in the more or less immediate neighbourhood. But the discovery of the "Black Band seam" by Robert Mushet, in 1801, which turned out productive beyond anticipation, and which from its peculiar constituents rendered the smelting a comparatively easy and economical process, enabled the Scotch iron masters to enter the list of competitors with English makers as producers of pig iron, abundant in quantity, fairly good in quality, compared with like iron in England, and produced at so moderate a price that they became formidable competitors with the iron masters of the South, and now hold a high rank as large producers of "pig." The manufacture of this class of iron has in the past practically constituted the iron trade of Scotland. It may still, with certain remarkable modifications, such as the extensive use of Cleveland ore, be said to do so; the making of wrought iron, still less those new products, with their new processes, the introduction of which into the iron trade of England and the Continent has constituted the great feature of the history of the iron manufacture, having had comparatively little place in the districts north of the Tweed till recently. With the prospect, however, of some process for getting rid of the "debasing" constituents of iron ores—and those of Scotland are by no means remarkable for the absence of those—such as the de-phosphorising and de-sulphurising system above alluded to, now so widely known as the Thomas Gilchrist, there is also a prospect of the Scottish iron masters turning their attention to other branches of the trade than that mainly or chiefly of pig iron. The Steel Company of Scotland, of which Mr. J. Riley is the able manager (a name well known in the iron and steel trade), is a good example of what may yet be done in this direction.

As to Ireland with regard to iron, the same remark pregnant with the gravest issues to the Irish people, full of most suggestive meaning in far more than one direction to the people as a whole of Great Britain can be made which has not been seldom made in regard to other departments of industry: resources abundant, resources not availed of. Although we by no means admit that it is foreign either to the scope or scheme of our work—for the subject is of vital importance to the interests of the engineering and the mechanical world—still it is idle here to inquire why the resources of the iron trade, or, to put it in another form, why the materials so abundant and so valuable to the iron master are not availed of. One thing at all events is very certain: it is as little for lack of opportunities as it is for lack of inducements to create a trade and make money that these resources are not availed of. Opportunities and inducements exist in Ireland not a whit less powerful than in England and Scotland, and yet they are permitted day by day to pass away, to die out unheeded. Individuals there are, not a few, who would be willing, are indeed now willing, to change all this decadence and decay—for Ireland long ago had her numerous, if, like those in England at a corresponding period, they were small iron works—and create a bright future by creating a wide industrial sphere of work which has never yet been realised. Work which would bring other sources of work and labour with it; for it has ever been a characteristic of progress in the arts and industries, that the necessities of a new or improved branch of work brought with them, or created, other branches to supply other necessities, each in one sense independent of the other, yet all connected or bound together, as links form a united chain, by the tie of a common interest.

We are now prepared to enter into details connected with the making of iron in the form of what is known popularly as a working metal, used in construction of various kinds. This metal, or what are in general trade known as the "irons of commerce," exists for working purposes in two forms—cast iron and malleable. So far as the making of iron or the labour of the "iron maker" is concerned, cast iron is known under one designation or technical trade name —that is, "pig iron." As regards the other iron of commerce, which we have named above, the other and indeed the more generally used name is "wrought iron." The distinctive characteristics of these two forms of working irons, the origin and derivation of their names, will hereafter be noticed in proper place.

Iron, to use the generic term, is produced from a mineral product found, as a rule, imbedded more or less deeply in the soil from which it is dug or mined in the usual fashion met with in obtaining subterraneous products. This mineral is known popularly as an "iron ore." Iron, as an element or constituent of the globe, is present in such abundance, and is so frequently present, that it would scarcely be exaggeration to say that it is, like air, everywhere present. We carry iron with us in our own bodies, for it is found to be present in the blood. Of its vast services to man we need say nothing here; they are to be met with everywhere and always.

Iron does not exist in its pure state as a metal. Metallic iron, as in its pure condition it is otherwise called, is never found in the earth, it being always accompanied by other substances, which will be noticed presently, and which are, in the technical language of metallurgy, said to be "debasing" constituents—that is, they not only lessen the proportion or percentage of the metal or metallic iron which the ores contain, but tend more or less, in a variety of ways hereafter to be described, to deteriorate the value of the workable metal obtained from them. The percentage of metallic iron which ores contain varies very much between a certain range—say from 50 per cent. or a half, and lower, up to 60. So also do the constituents themselves, other than the metallic iron, according to the formation in which they are found—within a range beginning with very poor up to rich ores. The nearest approach to pure metallic iron met with *on* the earth—but not *in* it—is what is called meteoric iron; in other words the "meteoric stones," so called—aerolites—or solid blocks which are projected from the heavens, and by the velocity with which they descend are often deeply imbedded in the soil. It is quite possible that the rare masses of what are said to be native or natural metallic iron have been meteoric blocks so imbedded, which have been dug up. It seems to be pretty well established that such a substance or material as pure metallic iron is not present in the earth, or at least within the limits into which man can dig or mine. The percentage of metallic iron in these meteoric stones is very high, varying according to different analyses from 90 to 98½ per cent., which latter is within a trifle of pure iron. These meteoric stones, consequently, can contain very little of other constituents: there is, in fact, but another present, and that is the metal called nickel—so that practically they are masses of metal, bringing with them from the "mysterious regions in the sky," in which at one time they circulated, none of the debasing elements so often met with on this "vile earth of ours," as some misanthrope, who had no eye for its marvellous and many beauties, has so deigned or dared to call it.

Unlike these foreign or heavenly bodies, the iron or metallic ores found in earth are always associated with various constituents of the globe's body—such as the commonly-met-with and well-known substances of lime, magnesia, sulphur, and water; and others less known, such as phosphorus and manganese.

THE STEEL MAKER.

THE DETAILS OF HIS WORK—THE PRINCIPLES OF ITS PROCESSES—THE QUALITIES AND CHARACTERISTICS OF ITS PRODUCTS.

CHAPTER VII.

AT the end of the preceding chapter, in describing the process of reduction of the ores in the production of steel, we stated that at a certain point the supply of gas from the producer is cut wholly off. This at the "critical" point of the process prevents the access of sulphurous acid gas to the ore, which would otherwise absorb sulphur from it with all its known evil effects. The heat in the drum now rises with rapidity, and the earthy constituents of the ore are fused, and coincident with the continued reducing action going on. Some ninety minutes after starting this point is reached, and when it is so, the "charge" is thrown in, composed of a mass of almost pure metallic iron, together with a liquid or floating mass of "cinder," composed of the earthy constituents and foreign substances of the charge. The "cinder," or slag as it may otherwise be termed, is then drawn almost wholly off, the rotation of the drum being stopped for this purpose with the discharging door at its lowest point. This being done, the discharging door is closed and the drum again put in motion, but at a higher speed than before; and at this stage, in order to facilitate the agglomeration of the metallic iron, a "rabble" or puddling bar is introduced, and worked as long and as energetically as desired, forming the mass into balls or blooms. These, by tongs hung from pulleys running on overhead rails, are taken out in rapid succession from the drum and passed on to squeezer rolls, by the action of which the adhering cinder is expelled. Thus treated, the balls are taken at once to the "bath" of the open-hearth steel converting furnace, known as the Siemens-Martin, shortly to be described in a succeeding chapter. The great purity of the metal, says Dr. Siemens, thus reduced from the ore, and the rapid and comparatively inexpensive nature of the reducing process, are conditions highly favourable to the production of steel of high quality by this method at reasonable cost.

Sir William Siemens, as we are led to understand, was at the period of his lamented death—a loss to practical science not easy to estimate—engaged in his efforts to produce steel direct from the ore, and the method and apparatus just described is competent to produce, and, as we have seen from last paragraph, has produced it. But from the last sentence it will be perceived that, at the stage up to which we have brought it, the main object it is designed to serve is rather as the producer of an iron which, from its extreme purity, is well fitted to make in time a steel of high quality by a succeeding process, than the making of steel direct from the ore in the rotating vessel. The purpose which the process is designed now to serve occupies in fact the same position to the final steel producer used by Dr. Siemens—namely, the "open hearth," heated by the gas regenerative furnace—as the use of malleable iron of good, or of the highest (as Swedish Bar) known quality, bears to the "cementation," "ordinary" or "Sheffield" process of steel making, to be described in a future chapter.

We now come to describe the ordinary methods of making steel from manufactured iron—that is, produced from the ore by the blast-furnace, as cast iron—this again changed by the reverberatory furnace and by the puddling process into wrought or malleable iron, which final product of the iron manufacture is taken by the steel maker to form his steel out of (see the section entitled "The Iron Maker"). In preceding paragraphs we have called the ordinary method of making steel a "roundabout" process: the reason for this we shall presently see; meanwhile we perceive from the above that if it be a straightforward one, it is one made up of several stages, beginning with the ore and ending with the steel. This process now to be described, although in one sense an indirect and what may be called an unscientific one—inasmuch as we first make pig iron with a certain amount of carbon in it, take this carbon out of it in changing it into wrought or malleable iron, and then by passing it through the steel making process give this carbon or a part of it back again—is nevertheless, with all its defects, the process by which we obtain the hard yet tough metal from which we make our finest steel goods, our sharpest and keenest and yet most durable of cutting tools and instruments.

If the reader has carefully studied the matter given in the paper entitled "The Iron Maker"—which, properly, should be taken up before the study of the present paper—he will know how such varied qualities of iron are obtained, and how, more or less, all varieties of iron have constituents present which tend in proportion to deteriorate their value. Roundly speaking, the comparative purity in value—for all our ores are more or less debased—of the ore decides the value of the iron produced from them; although the style or system of working has an influence, good or bad as the case may be, upon the quality of the iron produced.

It is scarcely, therefore, necessary to say that, as the metal required is a higher product than the iron from which it is made, the best iron possible is selected for the purpose of making steel. We have seen in "The Iron Maker" that of the different varieties of iron in the market, the "Swedish" has long stood, as it still stands, at the head of all our commercial irons. This high value is obtained, as the reader of "The Iron Maker" will have seen, by using the finest ores which are found in Sweden, reducing them, not by coal or coke, but by charcoal, which is the fuel giving the finest results; and in giving the greatest attention to all the details of the reducing or smelting, and to the succeeding processes by which the wrought iron is produced.

Bars of this fine Swedish charcoal iron are selected, cut into the proper lengths, and put into troughs or chests made of refractory materials calculated to resist the high temperature produced in the peculiar furnace employed known as the "reverberatory." Those chests, boxes, or troughs—the first name being that most frequently employed—are usually of a length of fifteen feet, having a depth of some two-and-a-half to three feet, and a width about the same. Before proceeding to fill the chests with the bars to be "converted" or made into steel, a layer of coarsely ground wood charcoal—that made from the hard woods being preferred—some two-and-a-half inches in depth is placed on the bottom. On this, as a foundation, the first set of the wrought-iron bars are placed, and so that a clear space of some half to three-quarters of an inch is left between them. On the first layer of bars being laid or set in the chests, they are covered with charcoal to a depth of an inch or thereabouts; the charcoal being softened so as to fall into and fill up the spaces left between the bars, while covering them to the depth named. The chests are thus filled with alternate layers of charcoal and of wrought-iron bars, until the top is reached to within about six inches. This final space is filled up with a species of luting material, made up of spent charcoal—that is, the charcoal resulting from a preceding charge, and waste from the grinders' wheels—along with water, to admit of its being spread over. Finally, the chests are covered with clay or dampened sand, this being done to keep the air from contact with the layers of charcoal and iron in the chests. The outlet doors and openings of the furnace are then closed, the fuel being first laid in place and then set fire to. Burning gradually up, the heat in the course of a few days arrives at the proper temperature required; it is then maintained at this for a few days longer. The length of time to which the chests and their contents are so kept depends wholly upon the purposes for which the steel is required, or the degree of carbonisation of the iron. To test the progress of the process, the bars are from time to time taken out of the chests; and, when the proper stage is reached, the fire is heaped up with small coal and then allowed to die out. The weight of steel in one furnace depends upon circumstances, varying from fifteen tons to twice this weight. The time occupied by the process may be taken on the average at three weeks. The length of the period of carbonisation of the wrought iron put into the chests, the weight of fuel required, and the consequent labour required from the commencement to the completion of the process, adds so very materially to the original cost of the iron employed, that the reader may well understand how that of the final product of steel is so high.

We have, in the process of steel making on this the "cementation" or roundabout system, from the cast or pig-iron, a gradual progress in change of material, and a gradual rise in price. We begin with the crude produce of the blast furnace, the cast or pig iron, with its low price per ton; we make this into a product of a higher class in constructive value by the reverbatory furnace, or by almost always the last-named process—puddling; and the wrought or malleable iron obtained brings in the market a much higher price than the cast-iron; and lastly, we take this wrought iron, and by the cementation process just described we obtain the iron changed into steel, which brings the highest price of all the forms which the metallic iron of the ore is made to assume by the art and the skill of man. The reader will understand how the old trade of steel making seemed about to be revolutionised, if not done wholly away with, giving the old steel makers a new outlet for a new form of labour, when the Bessemer process burst upon the world; or rather, we should say, how after going through the almost inevitable stages of obloquy, reproach, doubting, and sneering, and meeting with the usual difficulties attendant upon new processes, it showed itself capable of doing work in its own way, and that in a style as brilliant for its success as it was startling in its novelty.

Thus far we have traced the progress of the "cementation" process of steel making. After the furnace has cooled down—which takes about a week to complete—the bars are taken out. Their surface appears to be covered over with "blisters"; hence the name "blistered steel," given to the product of the cementation process. Those surface blisters are irregularly placed over the surface of each bar, and as a rule cover them but partially. The complete change effected in the original wrought iron put into the chests by the cementation process, as now described, is seen when a bar is broken across. This breakage, or, as it is technically called, transverse fracture, is done with ease as compared with the force required to effect a like fracture in the wrought iron. This is so constituted that its chief characteristic is the fibrous or thread-like condition of its molecules; those so tenacious that the bar is divided more by rupture than by breakage—using the terms in their popular acceptation.

THE DOMESTIC HOUSE OR HOME PLANNER OR DESIGNER.

THE WORK OF THE YOUNG ARCHITECT OR BUILDER IN THE DESIGNING OF HOUSES FOR TOWN AND COUNTRY.

CHAPTER XI.

AT end of last chapter we referred to the Paris plan of so arranging the "flat system" as that the whole flats or stories or separate houses are under the care of a general superintendent, who goes by the name of the *concierge*. He or she lives in a very small crib, as some one would call it, like the "cobbler's stall" immortalised by the celebrated Matthews the comedian, which served him for parlour, kitchen, and (hall)—"everything" as his reading had it. This small apartment is at the entrance, so that every one wishing either ingress or egress must gain it by attracting the attention of the concierge, who thus keeps up a surveillance of all comers and goers, often preventing the entrance of suspicious and more than suspicious characters. It is the duty also of the concierge to see that the entrance and the stairs leading to the horizontal houses, so to call them, are kept clean and well ventilated; and it is pleasant to note the difference in these respects between these parts of the building on the Continent and the corresponding places in the "flat" system of some buildings in this country.

Great, however, as are the advantages of the "flat," or "horizontal," or "one-floor house" system—this latter name, which we here give it for the first time, being perhaps the most distinctive and suggestive of its features—it will, we fear, be long before it is much availed of in England. The separate or "detached house" system has held so long and undisturbed a reign here, and every one is so accustomed to its independent comforts, that it will take a long time before many can be prevailed upon to initiate living in the "one-floor house." A course of education will have to be gone through first, and the difficulty is so great in beginning the lessons, so to say, that it is doubtful if it will be begun at all, seeing that even the most sanguine of house-building speculators will scarcely venture to erect houses on any plan, however good it may be said to be by its advocates, if they are not likely to be tenanted and paid for. Nor is it the least unfortunate circumstance connected with the new movement—if such it can be called—that those experiments made in connection with it in the Metropolis on the Westminster property and elsewhere have not been altogether successful,—which, however, need scarcely be matter of surprise on taking all things into account.

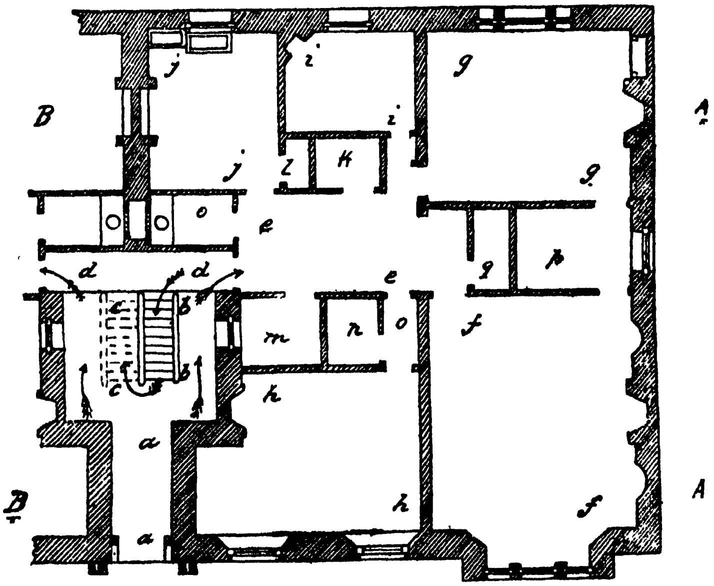


Fig. 8.

Suggestive Plans of Street Houses on the Scottish or "Flat" System.

We now come to describe the street house on the Scottish "flat" or "one-floor house" system, illustrated in figs. 8 and 11, fig. 8 being ground plan and fig. 11 front elevation, and which will show the English reader its peculiarities. The arrangement of the apartments is essentially the same as that adopted in the north, save that we have so planned it as to give to the house a larger number of conveniences, such as pantries and small bed and linen closets, than is usually given in Scottish houses of the kind; although it is only right to say that of late years, greater attention having been paid to planning, houses more recently erected in some districts give so many conveniences of this kind as to leave but little of anything to be desired. As a rule the "flats"—each separate story being called a flat, corresponding to the English floor—are precisely the same, with the exception that in some (and this according to the modes adopted to give entrance) the upper flat of all may have the space or part of the space of the lobby given to one of the rooms; thus, to the topmost flat of all the space occupied by the central passage or lobby *a a* in fig. 8 may be given to the extent of one-half of its breadth, the thickness of the partition to form a closet or wardrobe closet to the bedroom *h h* and to the corresponding room in the house occupying the space B B to the left. This may be done because the staircase may be lighted by means of a skylight in the roof; but it is obvious that the lobby space *a a* in fig. 8 cannot be utilised in the "flats" between the "ground flat" floor and the "top" or uppermost "flat," inasmuch as the lobby and staircase have to be lighted from the window, as A A in fig. 11, which window is at the outside end of the lobby above the street doorway, at *a a*, fig. 8. In fig. 8, which is ground plan, *a a* is the "entrance lobby" or "passage" leading directly from the street, one or two steps leading from the pavement to level of lobby. The "stairs" leading to second flat or story by two flights are at *b c*, the return flight *c* being shown in dotted lines, *d d* the "passage" leading to the two houses right and left. This passage on the upper stories or flats is the "landing" at the head of the flight of stairs. The houses are at each side of this, and the accommodation in each is indicated by the following letters. The "entrance hall" or "lobby" is at *e e*; the "dining-room" is at *f f*; "drawing-room," "parlour," or "sitting-room" at *g g*; *h h* "principal" or "front bedroom"; *i i* "back bedroom"; the kitchen is at *j j*, with "bed closet" for servant at *k*; "coal place" at *l*; the "second bed closet" at *m*; third or "principal bed closet" at *p*; *n* "pantry" or "larder"; *o* "water closet" at entrance door; and *q* "china closet."

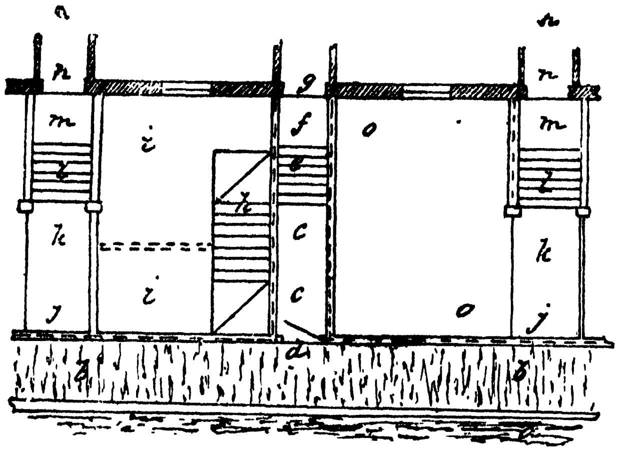


Fig. 9.

Remarks on some Defects of the Scottish or "Flat" System of Street Houses.

The arrangement of apartments here described is the same in all the flats or floors or stories, no matter how numerous they may be. The top flat or upper story may be modified in the way we have above indicated, by allotting the landing space as a closet to a front bedroom. And the lobby, as *e e*, fig. 8, may be lighted fully by a skylight.

The great defect of the Scotch "flat" system, as generally carried out, is the want of means for lighting the interior lobby or entrance hall, this being almost invariably placed in a central position, and only dimly lighted by a fanlight from the front door, opening into the staircase at landing *d d*, fig. 8, which itself is not so well lighted generally as it should or might be, or from borrowed lights above the doors of the various rooms—the latter, however, being, we believe, but seldom adopted. The second defect is that the bedrooms, both as regards number and size, are generally sacrificed to the desire to have large entertaining-rooms, as dining and drawing-rooms. A house highly rented and provided with these rooms of the handsomest description will have not one large and good bedroom, the best or principal bedroom even being but of small dimensions. And small dark closets are used as sleeping places even by members of the family, to the great detriment of their health, and assuredly to the loss of that comfort which a bedroom should give, seeing that it is the one room in which we spend the greatest portion of our lives and the longest intervals of our time.

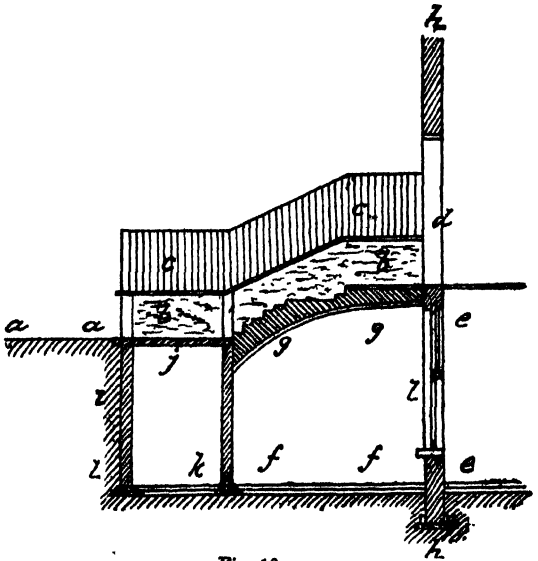


Fig. 10.

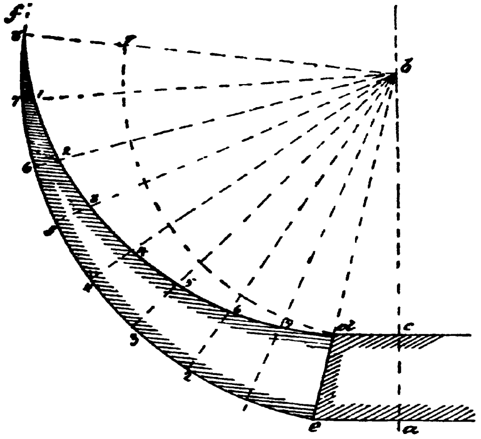


FIG.

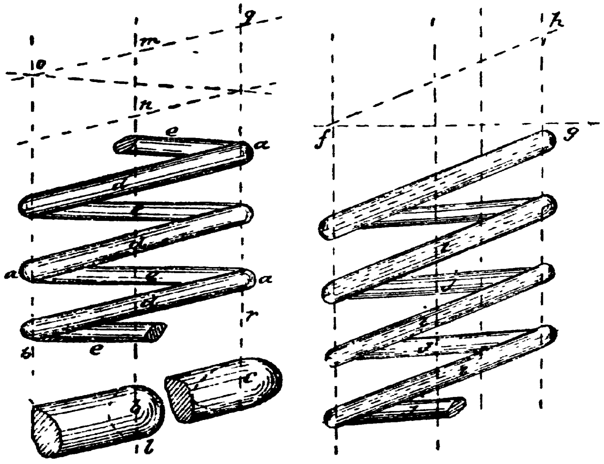


FIG. 2.

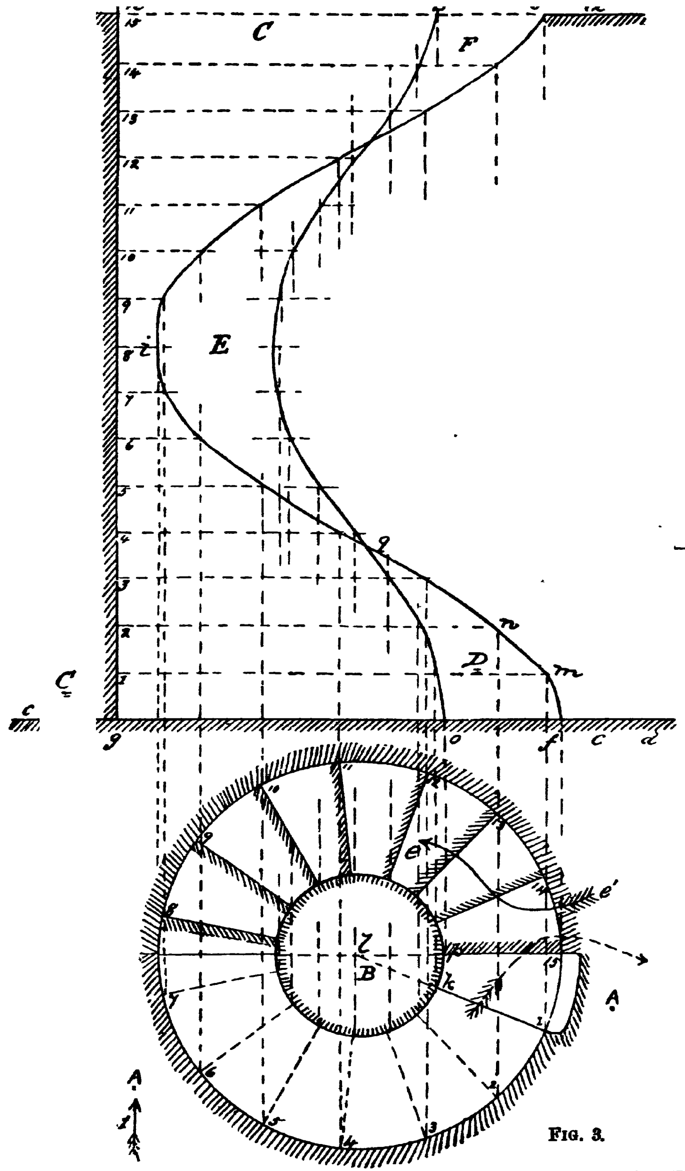


FIG. 3.

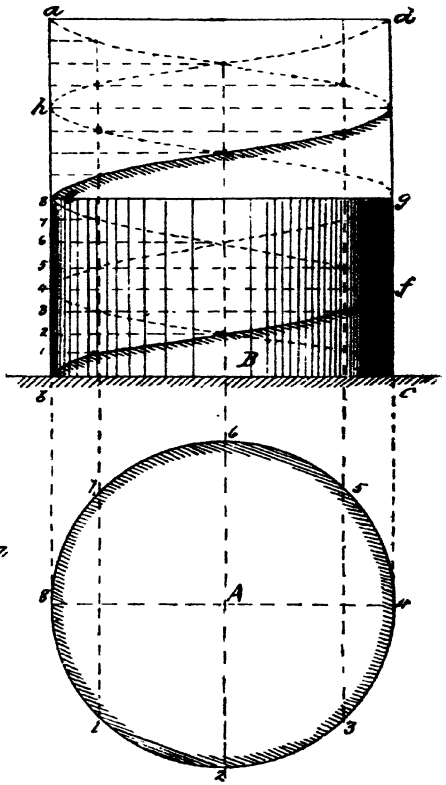


FIG. 4.

THE STONE MASON.

Doorways—Style Domestic Gothic, Figs. 1, 2, 2, 4, 5, 6; Style Elizabethan, Figs. 7, 8, 9, 10, 11, 12.

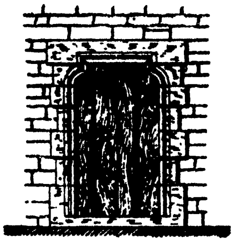


Fig. 1.

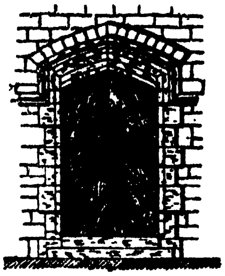


Fig. 2

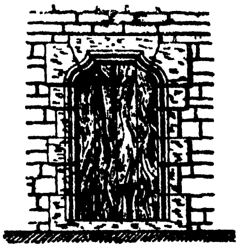


Fig. 3.

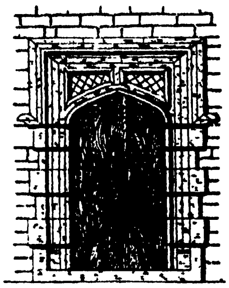


Fig. 4.

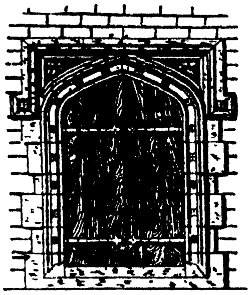


Fig. 5.

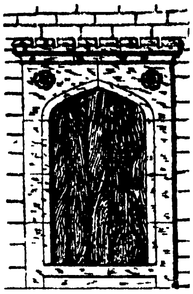


Fig. 6.

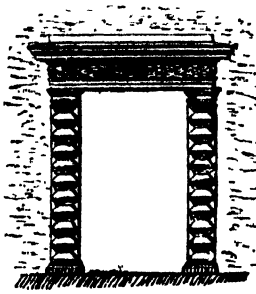


Fig. 7.

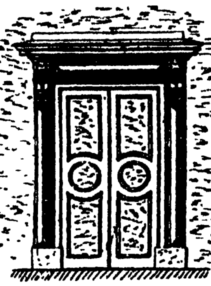


Fig. 8.

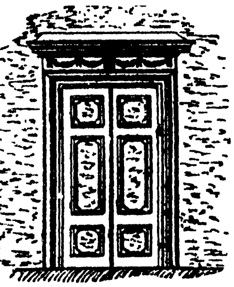


Fig. 9.

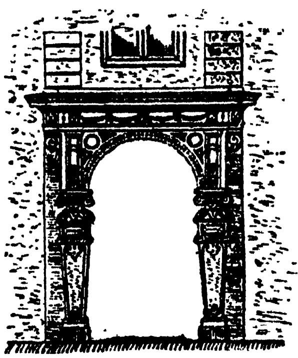


Fig. 10.

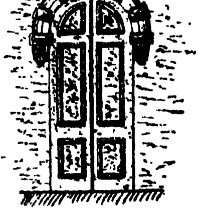


Fig. 11.

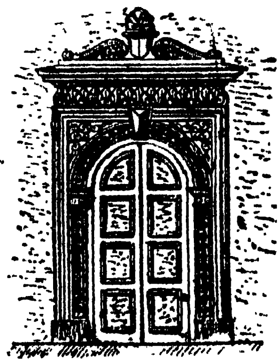


Fig. 12.

THE CARPENTER

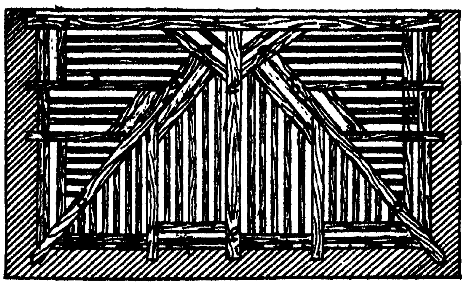


FIG 1.

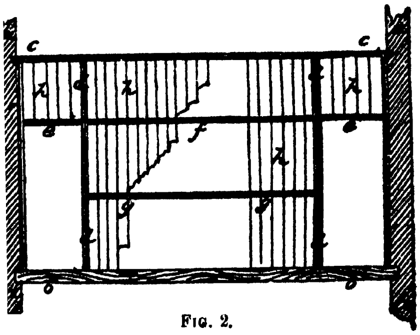
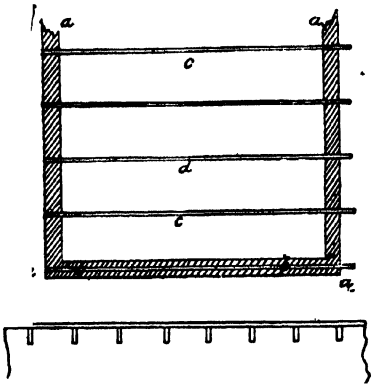


FIG. 2.



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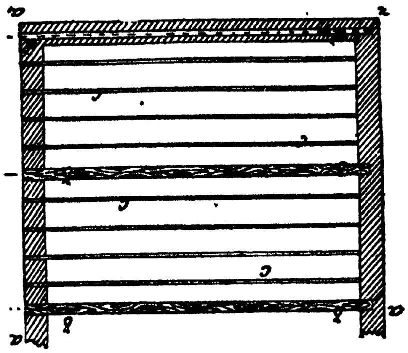

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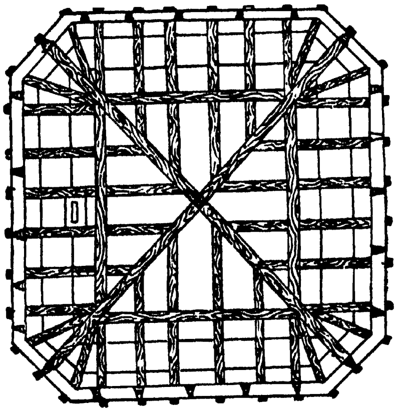


FIG. 5.

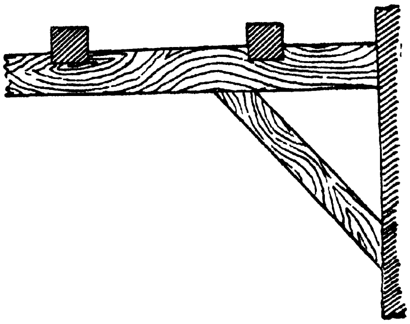


FIG. 6.

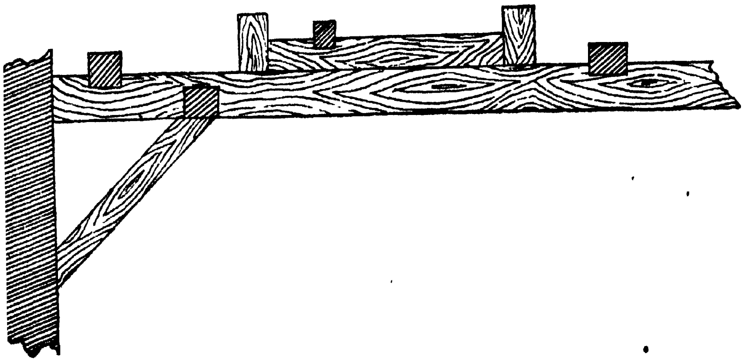


FIG. 7.

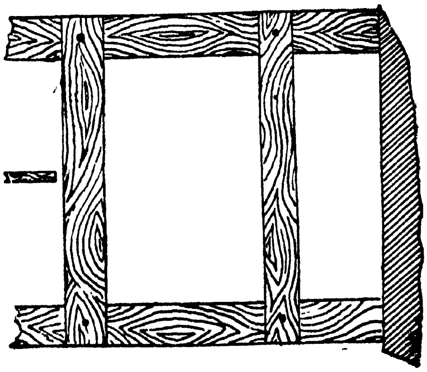


FIG. 8.

[Plate CLXXXVII

THE BRICKLAYER (*see Text.*)

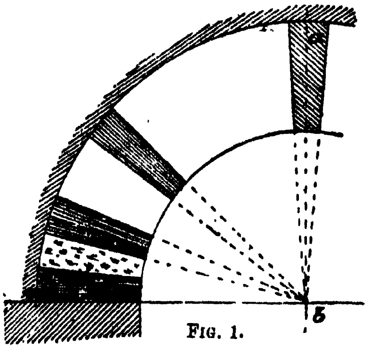
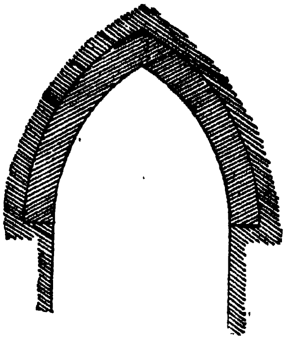


FIG. 1.



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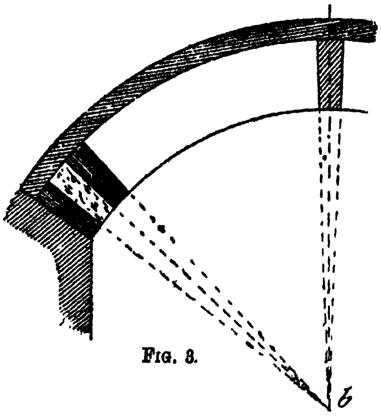

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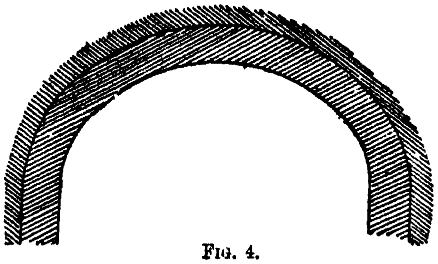

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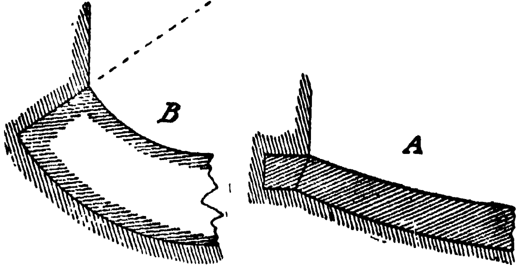


FIG. 5.

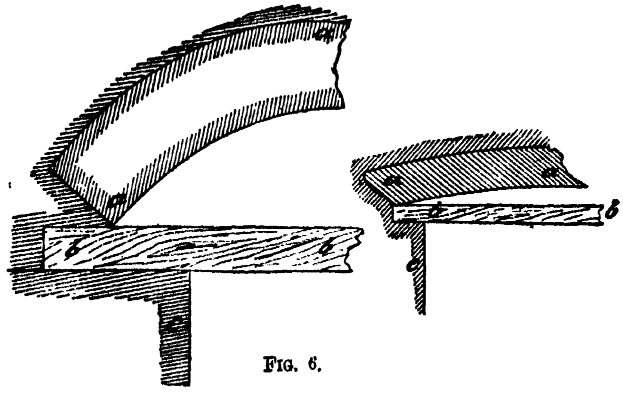
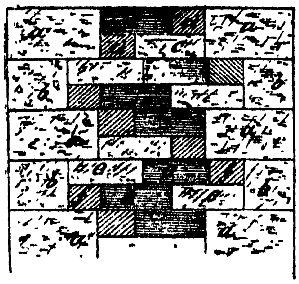


FIG. 6.



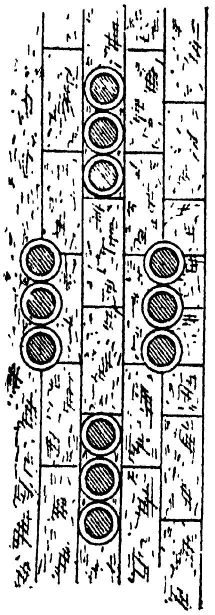
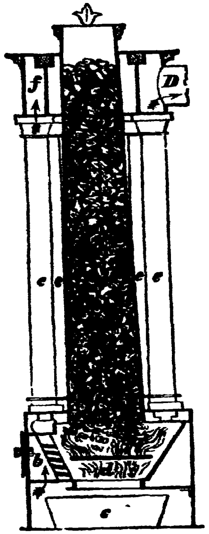


FIG. 8.

STOVES AND FURNACES.



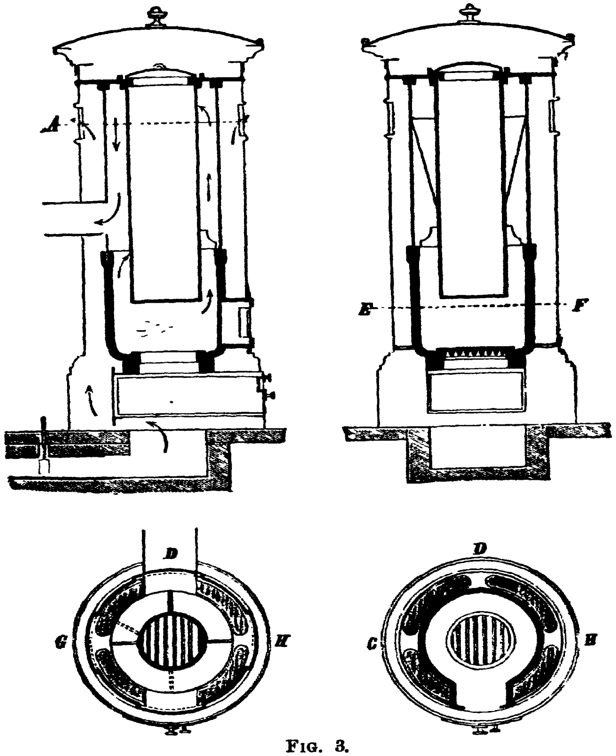
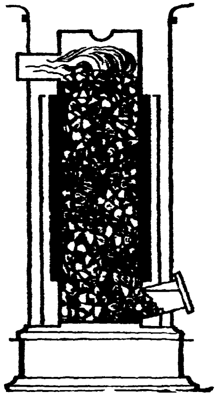
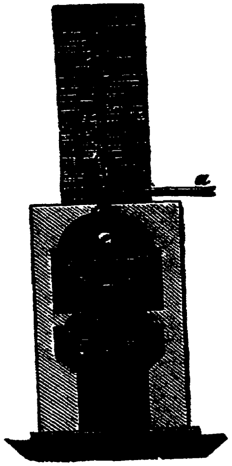


FIG. 3.





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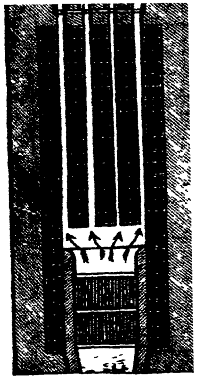

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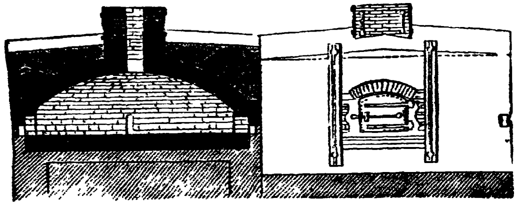


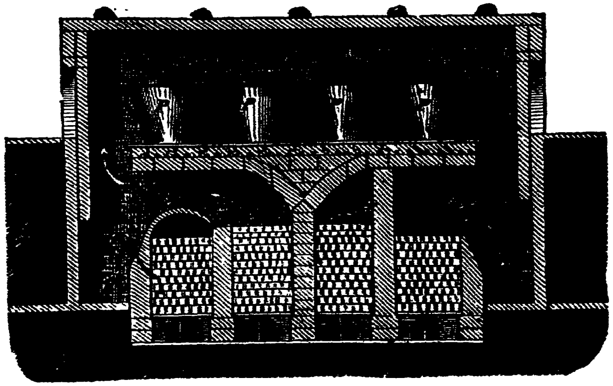


FIG. 7

THE IRON MAKER (*see Text*).

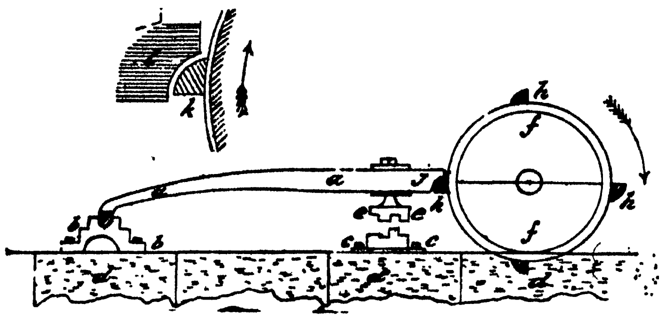


FIG. 1.

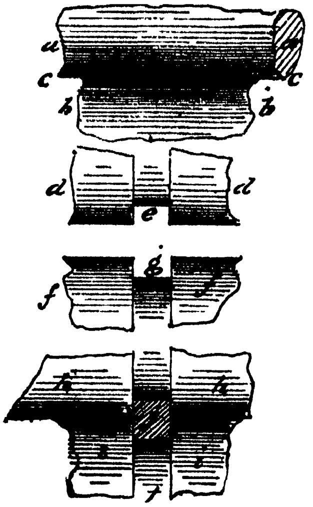


FIG. 2.

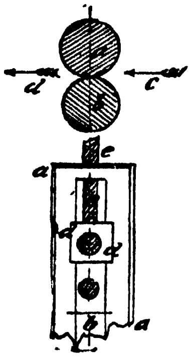


FIG. 3.

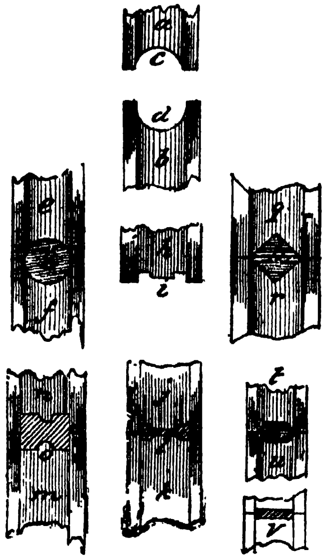
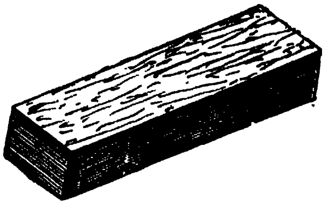


FIG. 4.



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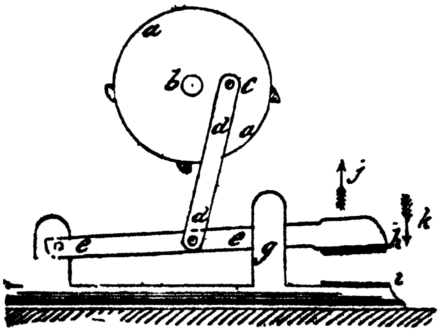


FIG. 6.

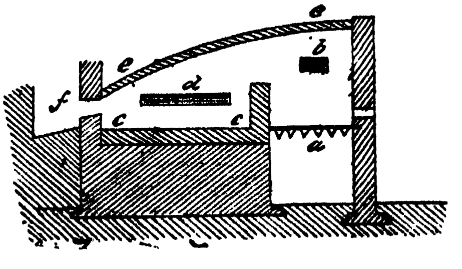
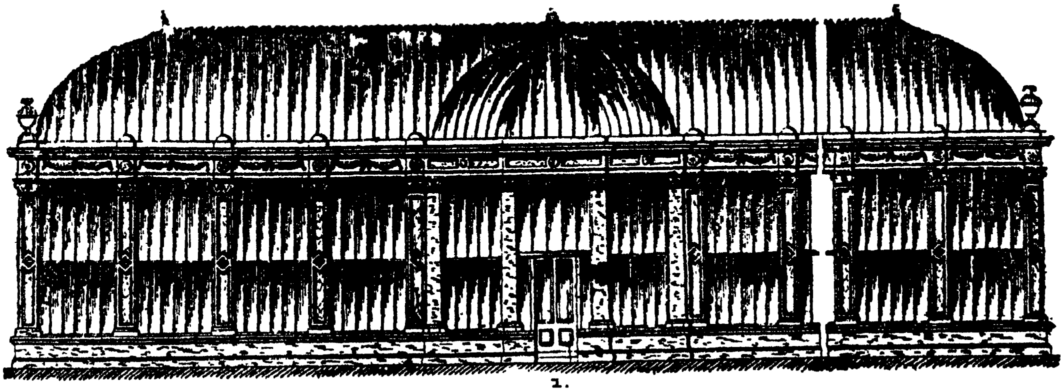


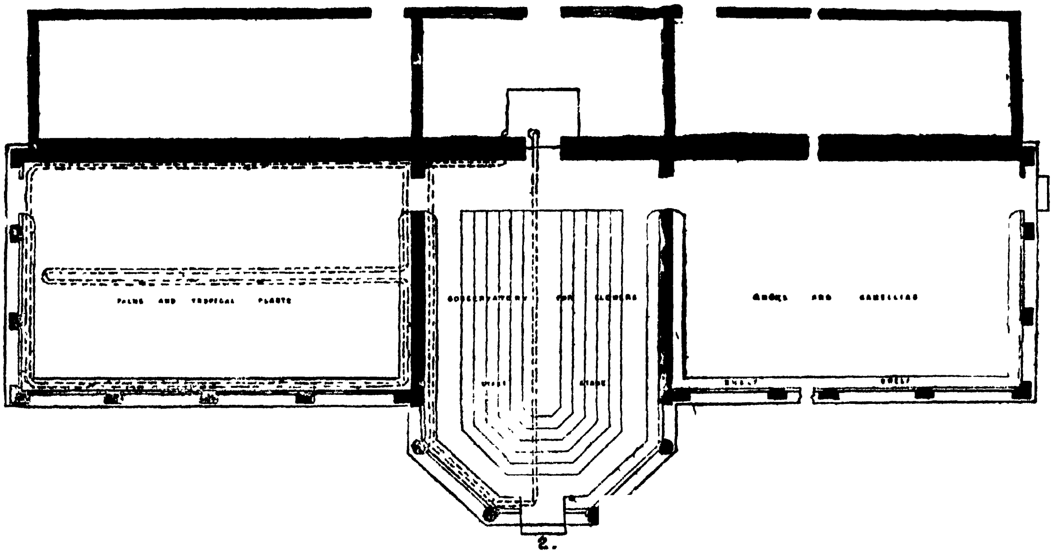
FIG. 7.

THE GARDEN ARCHITECT.



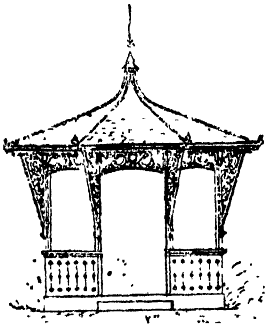
1.

FIG. 1.



2.

FIG. 2.



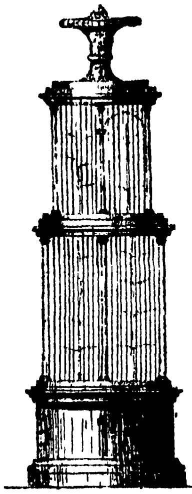


FIG. 4.

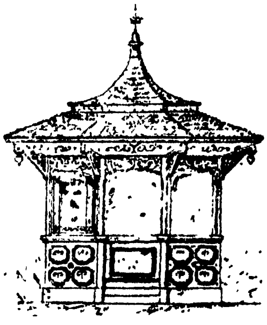


FIG. 1. ELEVATION OF CONSERVATORY. STYLE—ITALIAN. FIG. 2. PLAN OF DITTO. FIGS. 3 AND 5. GARDEN SUMMER HOUSES OR KIOSKS FIG. 4. AVIARY.

Front Elevation of House in Fig. 1, Plate CXXVII.

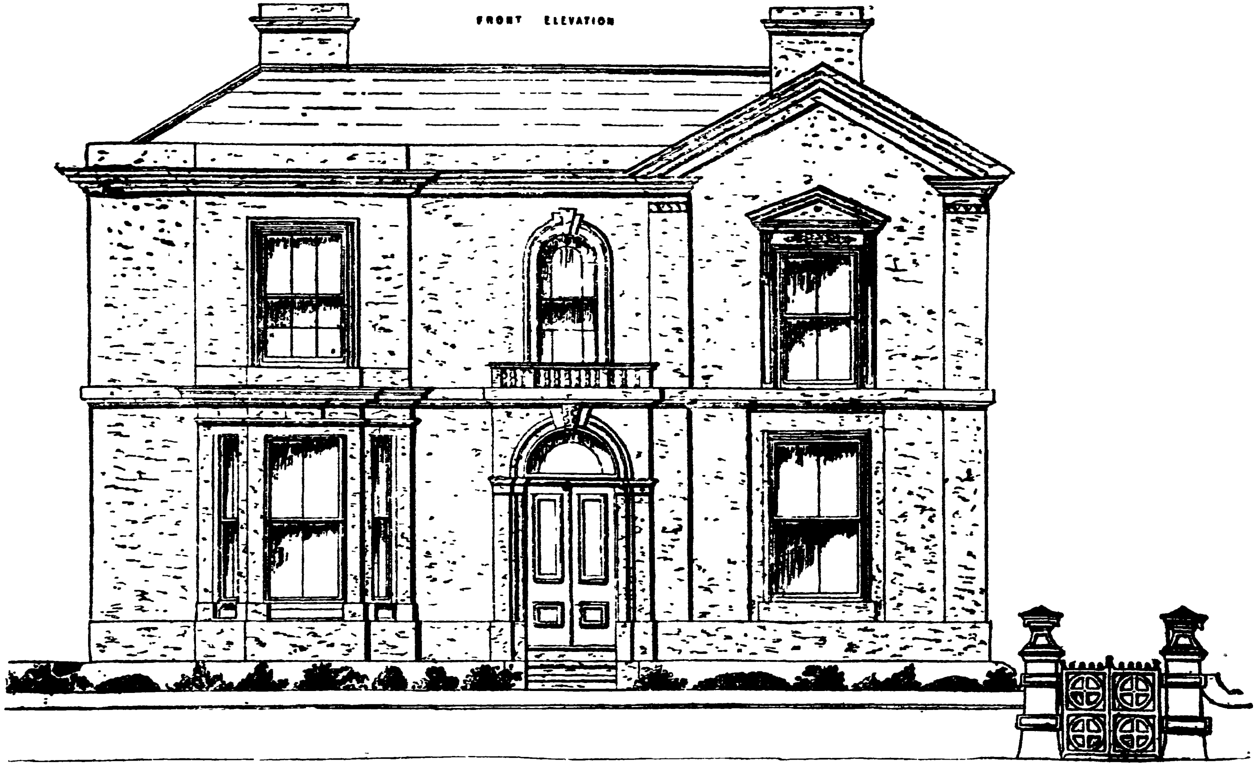


Fig. 1.

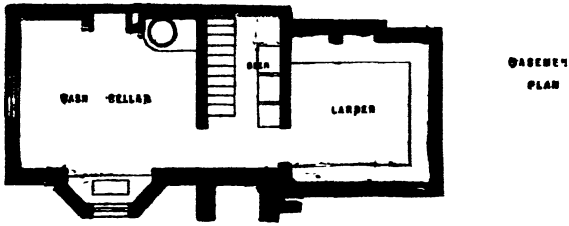


Fig. 2.

(See Fig. 3, Plate CXXVII.)

THE TECHNICAL STUDENT'S INTRODUCTION TO THE GENERAL PRINCIPLES OF MECHANICS.

LAWS AFFECTING NATURAL PHENOMENA—MATTER AND MOTION.

CHAPTER XXII.

AT the end of the preceding chapter we explained some of the terms connected with wheels of carriages. While the axle is firmly secured to and forms practically part of the body of the cart or carriage, the wheel is free to revolve on its hub. Each axle carries a wheel at either end, thus giving a wheel at each side of the cart; but there may be two axles, and thus four wheels. Each wheel supports its due part or proportion of the load—one-half of this if it be a two-wheeled, one-fourth if it be a four-wheeled cart or carriage. The wheels support their load at the hub, which takes the place of the centre, as of the ball or sphere *k* in fig. 12. If the carriage be standing upon level ground the condition is the same as in that figure : thus, in fig. 14 the line of direction of gravity or vertical line *g f* in first diagram falls or passes through the point of contact of wheel with the ground—that is, through the point *f*, upon which the wheel is supported; and if the carriage be placed on sloping or inclined ground, the conditions as in the second diagram in fig. 14 come into existence, with the same results, and if the wheels be free to revolve on their axles—that is, not "scotched" or acted on by the brake—the carriage runs down the incline to the level at its base. The majority of our young readers are well aware that it is easier to drag a cart or carriage over and along a road when it is provided with comparatively large than when it has comparatively small diametered wheels. The necessity for this arises from the roughness of the road surface, which is more or less incumbered with stones of various sizes lying upon or projecting from its surface. Where the rolling surface is comparatively smooth, as in an asphalted or concrete road, or where it is practically quite smooth, as in a street tramway, it is not necessary to have large diametered wheels. In the street tramcar, as our readers know, the wheels are of small diameter, approaching somewhat to the diameter of the friction roller. The conditions of wheels of ordinary carriages running on roads of the usual rough-surfaced condition is illustrated in fig. 17. In this we assume a small wheel, as *a'* in the first diagram *A*, meeting a stone or other obstruction, as *b'*. In the second diagram, *B*, we have a large wheel, *a c*, meeting an obstruction, *d*, of precisely the same size as *b* in diagram *A*. Under the most favourable conditions of draught, in which the force of the horse is applied, by means of the traces, to the carriages, the draught would be in a line represented by the arrow *c*, parallel or nearly so to the line on surface of the road *f g*. We have in this case the condition met with, in the easiest rolling motion, illustrated in first diagram, fig. 14 *ante*, in which, while the position of the centre *g* is running or moving along the line of rolling surface, this change of position or moving is done without raising the centre *g* at all, this running along parallel to the line *c d*. So in the second diagram, fig. 17, if no stone or obstruction, such as *d*, lay before the wheel *a c*. But when it does the drag on the wheel is in a position more or less oblique to the line of road, as shown at the line *a b* in the third diagram *c* in fig. 17; and this oblique force, which is in effect an upward pull, is required to lift the wheel (and therefore the weight of the load which is due to it—one-half if it be one of two, one-fourth if it be one of four wheels) over the stone *d*. In this the centre of gravity, as *a*, has to rise in a curve more or less pronounced, as *a c*. The flatter the curve is the more does its line approach that of the straight line, as *a g b c*, first diagram in fig. 14, which is parallel to the line of rolling surface *c d*, and which condition is essential to the easiest rolling. The difference in condition between a large wheel, as in the fourth diagram, *D*, in fig. 17, and a small wheel, as in the third diagram, *C*, meeting a stone of the same bulk, is shown graphically in the third diagram; the angle of draught is more oblique, as at *a b*; while the centre *a* has to rise and be lifted up in a curve, as *a c*, which is far removed from the flat and easy curve *a c* in the fourth diagram. The more the load is lifted or raised out of the direct line *a g b* in first diagram, fig. 14, the greater the loss in tractile power; and this is the condition where a small wheel, as in third diagram, fig. 17, is used. A large wheel lifts the centre comparatively little out of the parallel line, as shown by the flat curve *a c* in the fourth diagram.

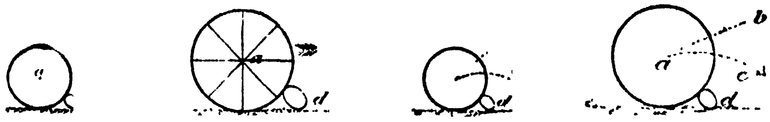


Fig. 17.

Specific Gravity.

At this point, before proceeding to the consideration of other and important principles of mechanics, it will be as well here to take up this subject; as it comes appropriately enough while considering the subject of gravitation specially.

What is called the "specific gravity" of a body or substance is dependent upon the property of density, or the mass of atoms in a given bulk. Here, again, the reader will see how interchangeable are the terms by which we indicate what are called the "properties" of bodies. For it will at once be obvious that a body possessing extreme "porosity" will in the same bulk or size or mass have infinitely fewer particles, molecules, or atoms in that bulk or mass than a body possessed of extreme "density," which must be of what we call greater weight. In ordinary language we say that the porous body is "light," the dense body "heavy." Here, again, those terms are purely relative; for, while it is quite true that a body can be called "light," it is equally true to say of it that it is "heavy." The condition is dependent upon its relation to some other body, with which it is or may be compared. If the reader remembers what he has read in previous paragraphs in an early chapter of this series of papers on the subject of the attraction of gravitation, or, simply, gravitation, he will understand that gravity and weight are synonymous terms, —the weight of a body being represented by some force which will prevent that body falling to the ground, if left free to fall, through the influence of gravity. And that force, if it can be measured, will be the equivalent of what we call, in popular language, the weight or heaviness of the body. All that is necessary is to have some standard body, or "weight," by which and from which we can make comparative statements or name what we call comparative weights. And in this standard weight we have the force of gravity, or the tendency of that weight to fall to the ground if left free to fall, represented; and if we oppose this weight or body by a "force" which is precisely equivalent to that weight, we prevent it from falling to the ground. In point of fact, we balance them, and the weight and the force can thus be represented or stated by the same standard. This standard in this country is called the "pound," and is equal to 7000 grains. This is the pound "avoirdupois," by which all common or ordinary substances or bodies are weighed—that is, have their specific gravities or gravitating power measured. The precious metals are weighed by another pound standard, termed the "troy," which has only 5760 grains, [See Tables of Weights and Measures (English and French) in "Technical Facts and Figures."] As we have seen that the force of the attraction of gravitation depends upon the distance of any position in which it acts from the centre of the globe, we see that this standard weight is in itself purely relative. For the higher we ascend or go into the air the less is the force of gravity, and the less by consequence, and in proportion, is the weight; so that a pound weighing 16 ounces at the surface of the earth will have a weight of less in the proportion, or thereabouts, of one ounce in every 100 lb. at a height of 10,000 feet. Practically, therefore, we assume that the standard weight of a pound has its gravity uniform in all the circumstances of ordinary life. And this weight is called an absolute—that is, a standard weight, and is assumed to be that at the sea-level, or the lowest point of the superincumbent mass of air. As the bulk of a body depends, as we have seen, upon its density or porosity—that is, the multiplicity or fewness of its molecules in a given bulk or magnitude, it follows that its weight or gravity will be in proportion to this amount of molecular matter, and hence that each substance possesses its own bulk, its own weight—a weight which is peculiar to itself only, *specially* belonging to it, and hence called its *specific* (or special) weight, or, to use the scientific term, its "specific gravity." The specific gravity of any body or substance being its weight as compared with some other body or substance of equal bulk, the term therefore denotes the comparative weights of bodies of equal bulk. Each substance or every body occupying a certain space, or possessing what we call bulk or magnitude, has under the same circumstances a weight peculiar to and invariably distinguishing itself: hence different bodies possessed of equal bulk must have different weights; hence, also, the reason why we say that one body possessed of the same bulk as another has a weight or specific gravity different to that of another body of the same bulk. Thus the bulk of two bodies may be similar, yet one body may have an absolute weight greater than that of the other. As may be readily conceived, the specific or special gravities or weights of different bodies differ very materially. For the determination of the specific gravities of solid and liquid bodies, water is taken as the standard—distilled water, so as to be free from all impurities, and at a temperature of 60° Fahr., being its best conditions; for gases and aeriform bodies the ordinary atmospheric air is taken as the standard. The principle by which the specific gravity of bodies is ascertained depends primarily upon a law of hydrostatics exemplified by the phenomena dependent upon the plunging of solid bodies into or floating upon a body or bulk of water. This law may be expressed thus. Any body placed in water displaces or causes the position to be changed of a body or a bulk of the water precisely equal to its own bulk. And as the bulk of water which the immersed body has displaced was and must of necessity have been held up or sustained in the position it originally occupied by the rest of the bulk of the water by which it was surrounded, it follows, therefore, that the body placed or immersed in the water must itself be held up or sustained in the water with a force equal to the weight of the bulk of water which it displaces. Hence follows this: that if the weight of the body itself is greater than the weight of the bulk of water which it displaces, it sinks in the water; if the weight of the body be less than the weight of the bulk of water it displaces it floats, as the popular phrase is, upon the surface of the water. It is impossible to overestimate the value of this principle to the arts and sciences; it has, indeed, by one of our ablest expositors of physical science, been designated as "one of the most important discoveries which human sagacity has ever made." The principle or law owes its discovery to that master-mind of ancient classical times, Archimedes. As the story goes, this wonderfully gifted man was at one time much exercised in his mind in his attempt to prove beyond doubt, what was at the time suspected, that the crown of the king of Syracuse, which was said to be of pure gold, was not so, but was adulterated with a mixture of silver. While pondering over this difficult problem, Archimedes had occasion to take a bath. This was either so full that on going into it the water overflowed the edges of the bath; or, as he went into it, he perceived that the level of the water rose, and it occupied a higher line in the sides of the bath than before. In either case—and as the first named is clearly the most telling, we presume it to have been the one—the habit of thoughtful observation led Archimedes to conclude that there was a direct relation between the bulk of his body and that of the water which overflowed the bath, and his sagacious mind saw at once that, as he knew that no two bodies can occupy the same place at the same time, the space occupied by his body while in the bath must have been filled up before he went into the bath; and that conversely, before his body could, so to say, find a place for itself, it must displace sufficient water to make room for it. And seeing the relation between the two, the full value of the discovery so elated him that, thinking only of the problem which had been puzzling him, and forgetful of appearance, he rushed into the street, and, running along it, shouted out "Eureka! Eureka!" ("I have found it! I have found it!")

Specific Gravity (*continued*).—The Law upon which it is based.

We have said that the importance of the discovery of this law we have named cannot be overestimated; and as its points may not be easily understood or readily grasped by some, we refer them to one of the early paragraphs of the series of papers in this work entitled "The Boat and Ship Builder," where it will be explained in detail. From this law that as the force with which a body immersed in water is held up or floated, is measured by the precise weight of the bulk of the water which itself displaces, it follows that if we find out the amount of this holding up or sustaining force and compare it with the direct weight of the body itself, the special, specific or comparative weights will be obtained. This, it will be seen, flows from and is dependent upon the great law already enunciated; and on it the hydrostatic balance and the hydrometer are founded, and in both water is the medium with which the results are obtained,—the principle of which may be roughly exemplified thus. First weigh the body of which we desire to know the specific gravity in the ordinary atmosphere, and then weigh it in water; take the difference between the two, and divide the whole weight by this: the quotient will be the specific gravity of the body required.

Specific Gravity (*continued*).—The Hydrostatic Balance.—Bodies heavier than Water.

The diagram in fig. 18 illustrates the way in which the principle above stated is carried out in what is called the hydrostatic balance, which is in fact but a good, well-adjusted ordinary balance, *a b c d*. The body *f*, of which the specific gravity is required, is suspended from the dish *b* by a fine thread *e*, or—what is very often used—a horsehair; and then the weight of the body *f*, thus suspended from *b* by *e*, is balanced with great accuracy by known weights, such as grains, etc., etc., put into the opposite dish *a*. This, which is the actual weight of the body in the air, is noted down. If now a vessel of water—the mechanical arrangements of the balance being such that this can be readily done—be passed from under, so that the body becomes gradually immersed in the water, then, in virtue of the law we have already enunciated, the body *f* is, so to say, pushed up by the water with a force or pressure equal to the weight of water which it displaces, the result being that the body apparently loses so much of its weight that the balance between the two dishes or ends, *k*, *l*, of the balance beam no longer exists; and the dish *a* and end *k* of beam preponderate.

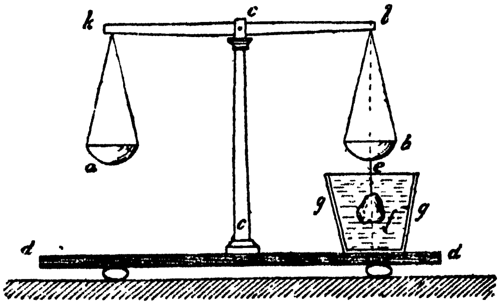


Fig. 18.

THE GRAZIER AND CATTLE BREEDER AND FEEDER.

THE TECHNICAL POINTS CONNECTED WITH THE VARIETIES OR BREEDS OF CATTLE—THEIR BREEDING, REARING, FEEDING, AND GENERAL MANAGEMENT FOR THE PRODUCTION OF BUTCHERS' MEAT AND OF DAIRY PRODUCE.

CHAPTER XVIII.

CONTINUING the subject of bulk as a characteristic of cattle foods, we may remark that any one acquainted with the habits of cattle knows how large the mass of food which they consume. When out at pasture they may be said to be continually eating, the time they are chewing the cud and at rest being comparatively small in amount. In the case of the horse its stomach is differently constructed, so to say; it is much less capacious than that of cattle. Hence, more concentrated or less bulky food is given to the horse, such as corn and hay, which of their respective classes are the most concentrated forms of food. But in all cases farm stock require a certain amount of bulk in their food. Hence it will be perceived by the reader, in referring to the analyses we have given, that there must be some mistake made in the purely chemical view of cattle foods when their "woody fibre" is classed as a *non*-nutritive substance. It is well known how important the part is which straw plays in cattle feeding; yet, by referring to the analyses, it will be seen that woody fibre makes up the largest part of the substances, varying from more than one-third up to nearly one-half of the bulk. It is no reply to this objection to say that this large proportion possesses no feeding value so far as analysis can show, and that it only serves to increase the bulk of the food. But as we have seen, and know for certainty, that bulk is absolutely requisite to insure the full development of the digestive functions of the animal, to state that the bulk only is the point gained by the presence of "woody fibre" is but another way of admitting that woody fibre is a nutritive substance, while nevertheless it is, according to the purely chemical view, set down as non-nutritive. And apart from the question whether it is or is not nutritive, a merely common-sense view of the point would determine that it is but a mere play upon words to say that the "woody fibre"—which, with water, also by the chemist classed, as we have seen, as non-nutritive, makes up the great bulk of food—is useless, while we know that it aids digestion, and without it digestion, in the proper sense of the term, cannot indeed be secured, without which the richest food is useless. Whatever is essential to the due performance of any work, however useless considered by itself, cannot, in any true sense of the term, be said to be useless. If we wish to boil water, the kettle is as much a part of the *act* of boiling as the water,—as giving the bulk or woody fibre of a food is as much a part of the act of feeding as the strictly nutritive parts of it.

Value of the Aid afforded by Chemistry in Farming.

We have been thus particular in insisting upon these points as affecting not only the value of foods but the act of feeding with them, not merely because they are important in themselves and lead up to considerations also important, but because we desire to impress the reader who is desirous to know what constitutes sound practice in the feeding of farm stock with this great truth: that the science and the consequent art or practice is not to be, cannot be, decided by the investigations conducted by, and the deductions drawn from them by the chemist alone. And in saying this we by no means desire to convey the idea that chemistry has done but little service to the science and practice of foods and feeding. On the contrary, it has absolutely created the science. Before the chemist took the subject up, it may be said, with almost absolute truth, that nothing was known as to how the difference was to be exhibited which existed between one food and another. All that was known was that differences did exist; but this, in great measure, was only guessed at. What was done in feeding was based upon a but too limited series of observations, and these made only by the intelligent few; while the great bulk of farmers did everything by haphazard, guided chiefly by preconceived notions and by prejudices. But chemistry changed all this: it told us of what foods consisted, and proved that there were connecting links which bound not only the foods themselves in what may be called a common bond, but connected them in the closest manner with the soils and the manures by which those soils were fertilised, and the value of the crops increased. In brief, it showed, in a manner as conclusive as it is beautiful in fact, the marvellous cycle of operations constantly going on in the vegetable and animal world: how the wants of animals were met by the vegetables, and how the animals in turn ministered to the necessities of the crops; the same constituents appearing in each, and each in turn taking its place in the beneficent arrangement of the material world. Farmers do not now need to grope in the dark, vainly inquiring how this and why this should be so; chemistry tells them what it is which constitutes the true value of practices which observation only had pointed out,—it tells them also what to avoid. And if it had done nothing more than to put into the hands of the farmer the means to ascertain what is the true value of the foods which he has to purchase, and which are now so largely used, and are offered to his notice by so many competing firms—and thus shield him from the dishonest tricks of the least respectable of dealers—chemistry would have done much for him. But we have seen that it has done vastly more than this: it has raised the practice of stock feeding to the dignity of a science, and has made this practice to a large extent definite and precise in its details, and rendered food much more economical than was the case under the old rule or method of working.

But while chemistry tells the farmer much—very much—of the highest value to him in his daily practice as a feeder, it does not, has not, told him all; although the chemist may say in reply that he only concerns himself with points of the subject within his province; that he only points out what his knowledge as a chemist enables him to do, leaving it to the professors of other and cognate sciences to fill up the gap which chemistry does not profess to do. This view of the relation which the chemist occupies to the whole question of cattle feeding would have been just enough had it been maintained; but, unfortunately, as we think, for the practice of feeding, Liebig—the first and great expounder, if he is not, indeed, to be looked upon as the discoverer of the science—took such a very decided view of what chemistry could do, and, as he maintained, did, that nothing was left, or considered to be left, for the expounders of other sciences to do. Hence it was that at first, and for long, it was held that the purely chemical was the true view of the question of food and feeding: hence the evils in practice which followed and all its consequent disappointments, and those so great that for years discredit was thrown upon chemistry as a practical aid to agricultural practice in feeding of stock.

Condition or State in which Food is, an Important Element in Farm Stock Feeding.—Cutting of Straw.—Slicing and Pulping of Roots.

But, just as we see in other departments of science the discoveries of one lead to those of another, the details which one leaves incomplete being filled in by another. Thus we find that where chemistry failed, and fails, in pointing out what are the circumstances in practice which modify, and tend to modify, the deductions made from its investigations and analyses, physiology steps in and completes the task. This we have so far illustrated, but the points concerned in this dual relation of the two sciences are not yet exhausted. We have seen that water and woody fibre play important parts in the action of food in the animal economy, and that, even while admitting the truth of the chemist's assertion that they are not nutritive, they form, so to say, such important links in the chain of food assimilation and digestion of the animals, that if absent, the chain incomplete fails, as it must fail, to do its duty. Looking upon those two elements of water and woody fibre for the present as acting in a purely mechanical or physical manner by adding to the bulk of food, the condition or state in which food is given to the animal exercises a decided influence upon its digestion and assimilation. Thus it would appear to be matter of indifference whether straw, for example, or roots, such as turnips, were given in their original condition—that is, the straw uncut and the roots whole. But in practice it has been found that if we cut the straw into short lengths—technically, in the language of the feeder, called chaff—from half an inch to an inch long, and if in like manner we cut the roots into thin slices, or, as some practical feeders prefer to do, shred them down into such minute portions that they form a species of pulp, we find that the processes of digestion and assimilation are so greatly promoted, that this style of feeding is more economical than that in which the materials are given in the whole state. The action of the materials would seem in large measure to be in the first instance merely mechanical, as by division increasing the surfaces, so that these will be in the best physical condition to be presented to the juices and the action of the vessels of the stomach. But we are inclined to believe that another result is obtained by this process of division or increasing of the surfaces, and also by consequence, and in large measure, the bulk of the food. And this result is, as we think, that alteration in the flavour, and consequently in the liking which the animal will have for it, which we know results from trituration of certain substances. Thus it is well known that neither the full flavour nor the full odour of certain plants and substances are developed until they are bruised, crushed, or triturated. So marked is this characteristic in some substances that in their normal or natural condition they give out no odour and when touched by the tongue almost as little flavour; but when crushed, bruised, or triturated, their odour and flavour are at once developed. The process of cutting straw or pulping roots is largely carried out in practice. So largely that it has given rise to a number of machines and appliances which have kept, and still keep, many agricultural machinists at work. This practice of cutting, dividing, crushing, and bruising is based, beyond a doubt, upon what experience has shown to be beneficial to the animal. Farm stock of all kinds are generally influenced by what is called taste—they having their likes and dislikes just as strongly pronounced as have men—and this is often shown in a way so decided that it is suggestive of somewhat grotesque or ridiculous thoughts relating to "man and beast," which the observant farm stock feeder is often greatly interested in.

THE FACTORY OR MILL HAND AS A TECHNICAL WORKER.

The Organisation, General Duties, and Special Work of the Staff of Factories for the Production of Spun and Woven Goods—that is, "Yarn" and "Cloth"—and those chiefly in Cotton and Wool.—General Description of the Various Processes of Manufacture.

CHAPTER X.

Continuing our description of the carding process commenced in last chapter, we have to state that the cotton is stripped from the doffer by a comb or knife. This is called the "doffer comb," or "doffer knife," and it leaves it in a fine fleecy condition. It is then brought to a funnel, where the fleece is condensed and made in the form of tape or riband called a "sliver."

The Coiler or Condenser of the Carding Engine.

The sliver is drawn through this funnel by two iron rollers (calender rollers), which are so regulated that they take up the web as fast as it is stripped from the doffer. It is then received by an additional machine, called a "coiler,"—but we do not wish it to be understood that it is looked upon as a separate machine, as all carding engines, as they are now made, have this part added to them. This can easily be taken away, if desired; but the advantage of it is so great that for the last twenty years it has been considered as indispensable. The "coiler," as it is called, is also provided with calender rollers, which are so calculated as to take up the sliver or tape at about the same rate as it is delivered by the funnel or calender rollers. In the arrangement of this coiler there is a place where a tin "can" can be placed to receive the sliver as it falls from the receiving part of the coiler (top part). The can which is placed to receive the sliver is round, and of about 9 or 10 inches diameter and 36 inches long. At the top part of the plate there is a hole, so that the sliver can go through. The hole in the plate not being in the centre of it, the eccentric movement causes the sliver to form something of a circle as the plate goes round, and thus the sliver is coiled as it drops into the can. Again, the bottom part of the coiler which carries the can is provided with a plate to carry the can, and this, by appropriate gearing, causes the can to turn round in an opposite direction, and this plate is driven from the carding engine in the same way as the calender rollers and the coiling plate at the top part of the coiler are driven. In this way the can is filled more regularly than it would be by allowing the sliver to fall naturally into it. There is also the advantage of pressing it down into the can without even the slightest attention of the attendant. The sliver being free from twist, it is so subject to entanglement that it must be treated with care, or otherwise much waste, loss of time, and inferior work would be the result. If the coiler were dispensed with, the labour in connection with the carding sliver would be muliplied fourfold.

The Carding Process for "Medium" and "Fine" Counts of Cotton Yarn—The "Flat" Carding Engine.

We have given a somewhat clear account of the working of the carding engine in general use in the coarse spinning mills. The carding engines in the medium and fine spinning mills are in every respect the same, in so far as the basis of the machine is concerned—*i.e.* the main cylinder, taker-in, doffer, feed rollers, delivering rollers, coilers, and in the way in which the lap is arranged at the back part of the carding engine. The clothing of the cylinders is in every respect treated as in the above, excepting that a finer-set wire is required for the finer kind of cotton and the finer yarns intended to be spun. This will be obvious to the reader, as in finer work all care must be taken in order that the cotton can be more freed from specks, or other matters which would produce unevenness in the thread (yarn when spun). In explaining the roller and clearer engine we stated that they covered nearly half of the main cylinder (top part). In the case of the carding engine (for fine counts of yarns spun), which is almost universally in use, flats are in the place of rollers and clearers. This change also causes a very different classification of framing to accommodate the flats to that which is required for the roller and clearer carding engine; however, this in no way interferes with the object of carding cotton. The different order of the machine frame is so made that the system of carding by flats may be carried out by flats instead of the roller and clearer principle. The roller and clearer system is, of course, so arranged that by rope or chain they are made to run round, but in the case of the flat system they are in a stationary condition (with the exception of one arrangement, which will be hereafter fully described).

Hand and Machine or Automatic Stripping or Clearing of the "Flats" of Fine or Medium Count Carding Engines.

Of late years the plan of flat carding has been entirely changed from hand labour to that of automatic. Formerly the stripping or clearing of the flats was done by hand labour, which was a laborious piece of work, not healthy, nor did the operative get a sufficient remuneration for this kind of work. It was readily taken up by men of little or no experience. This laborious and ill-paid work is now superseded almost entirely by automatic machinery, and with perfect precision.

Mr. Evan Leigh, while engaged in Manchester as a cotton spinner, being of a mechanical turn of mind, and certainly very ingenious, constructed a carding engine on the "flat" principle, to be self-acting in its cleaning operation. Immediately his plan was brought out and in operation in a few mills, an American system was brought into this country. It was a very ingenious method of what is called "self stripping," which means cleaning the wires on the flats. This plan was much admired, inasmuch as it did not disarrange the present appearance of form of machine; in short, it retained the old flats. This curious mechanical arrangement was at first so flimsy and intricate, that it was liable to continual breakages, and the machine was often at a standstill. However, in time the firm of Dobson & Barlow, Bolton, made many alterations in this mechanical arrangement, by which the breakages and other inconveniences were much reduced.

The firm of John Hetherington & Sons, Manchester, next gave another impetus to this system of self-stripping. Theirs, we may say, was a new arrangement, which, though it embodied the American "Wellman's plan," nevertheless had in it comparatively new arrangements to carry out the American principle of working. The method of cleaning, stripping the tops, was identical with the system adopted by the firm of Dobson & Barlow, Bolton—*i.e.* by lifting up the flat from its work, and thus so far reducing the carding power for the time. This is not of very great importance, because it is so quickly returned to its former position of working with the cylinder. The mechanism of this plan is not only ingenious, but very complete.

Self-Stripping Carding Engine (*continued*).—**Leigh's Machine.**

We now refer to that plan of self-stripping which we named at the outset of the subject of self-stripping, namely, that invented by Evan Leigh, of Manchester. We have not left it to the last to give its description for the reason that it is the only one which meets the demand. If it were the best in the world, it would not be looked to by every one as the best. Users of machinery vary in their tastes, their knowledge or ideas of certain parts of a machine, and they are influenced in different ways; and so it comes about that different machines are patronised by different men.

The method adopted by Evan Leigh of arranging and working his self-stripping is certainly simple. And all simple plans of working machinery are generally free from much wear and tear, and also from frequent breakages, which cause stoppages, and thus interfere with the production, as well as being a loss in the cost of repairs. The arrangement where the possibility of breakage is reduced to a mere minimum is the setting of eighteen, twenty, or more tops on one card. These are so easily set to their work in this arrangement, in comparison to those of the Wellman's principle, which have to be set separately, and which is a very tedious process, as the cards cannot be set so much alike as those which are all so arranged by a certain bevel on the flats. The system of setting flats on Leigh's principle is by thus setting them on a bevel. Where they have to be set mostly by guess, they cannot, even by the most systematic and careful experienced hand, be set equally throughout. Now, in the case of Leigh's plan, the whole can in that respect be accurately set to work. Each side of the cylinder has a bend, or circle, similar to that of the cylinder. This bend is somewhat flexible, and on this bend the flats are drawn over. The bend has three, sometimes five places for setting the flats nearer to the cylinder, and as the wire on the cylinder, and also that on the flats, wears, the five screws are lowered, brought nearer to the cylinder. This self-stripping arrangement is of the very simplest kind, and at the same time it is as correct as any principle we have ever met with. The plan adopted for the flats to be carried or conveyed on their journey—for they are really revolving flats—is as follows. An endless chain is used; two-fifths of it is continually on the cylinder and at work. It travels with a continual steady motion, driven by wheel and pinion; and thus fresh and clean wire is presented to the cylinder, which is exactly what is required, and what is also done by the others in another way, as before shown (Wellman's card principle). In this case the number of flats is continually the same; they never vary. The other principle alluded to having only a fixed number, when one is to be cleaned it is raised from the cylinder. In the case of Leigh's system, the cleaning of the flats is carried on in another way altogether—*i.e.* they are cleaned as they leave the cylinder by a comb and a brush. As a dirty one leaves the front of the card, a clean one is drawn in at the back, and this process goes continually on with mathematical accuracy. The "strippings" from the systems which we have treated are in all cases placed in a box or receptacle, in which the cotton which is taken from the dirty flats is deposited conveniently for taking away. It will thus be seen how, and in what way, the automatic system of stripping the tops is superior to that of hand stripping for regularity and cleanliness. As to the clothing of the tops or flats, the same kind of wire which is suitable for one is also suitable for the other—*i.e.* as regards the material they are composed of, and as to the fineness of the set of the wire.

Practical Remarks on the Two Processes already described—Opening and Carding, preparatory to the Next Process, that of Drawing.

In the preceding paragraphs we have given a full description of the two first and very important processes which the cotton fibres must pass through; and this in order that our readers may be furnished with particulars which will enable them to have a fair amount of knowledge of the operations to which the cotton fibres are subjected in the two first preparatory stages, and which are of the utmost necessity to be so regarded, in order that the final result or spinning may be satisfactory. As the next process will clearly indicate, opening up of the fibres of the cotton is not only important, but essentially required, and in this way it will be understood how important a part the opening machine has to take in the preparation of cotton. It could not in any degree be considered in a state suitable for the carding engine, unless it had been in some way operated on so as to open up or detach the fibres one from another. This, although so wonderfully well done by the blowing-room machinery, is after all not so completely done as thoroughly to clean it. The further separation of the cotton fibres is more perfectly accomplished in the carding engine, which we have already described; and besides more completely separating the fibres, the other objectionable parts, such as sand dust and short coarse fibres, are to a great extent cast out by the work of the carding engine. This is so far in favour of the next machine, the directions for working and management of which we now take up.

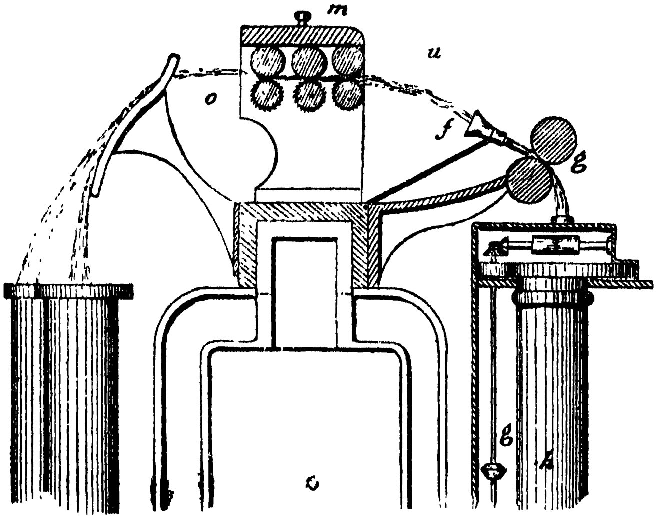


Fig. 8.

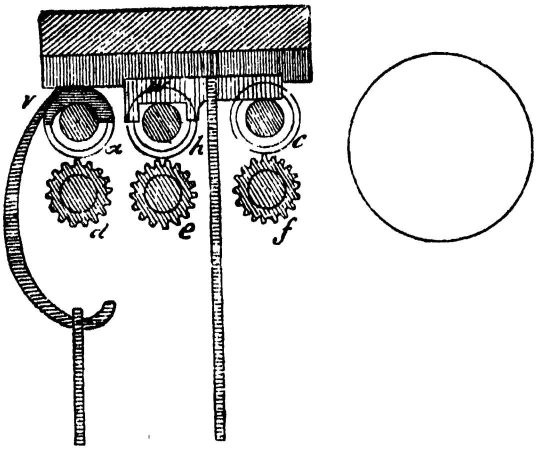


Fig. 9.

The Drawing Frame, the Machine next in use after the "Card."

The principle of this we partly illustrated in connection with fig. 6 (*ante*) in describing the finisher carding engine to which the drawing rollers were given. We now describe more fully the principle and the way in which it is applied in practice in the "drawing frame."

The object of the "drawing" process is to make the fibres in the slivers received from the carding engine still more parallel; it draws the slivers out more and makes them evener, thus causing the yarn to be even and strong, which are essential features in a good quality. The machine for carrying this out is called "the drawing frame." Three to five pairs of rollers are used, and the part of the apparatus used for drawing is called the "head." In such a machine there are three, four, or even more heads. To the explanation of the principle of drawing which has been given in connection with fig. 6, it must here be added, that the velocity of the rollers varies, and by changing the wheels the drawing can be diminished or decreased. The extent to which the slivers are drawn out depends upon the difference of velocity between the first and last pair of rollers, and the intermediate rollers have not any effect upon the extent of the drawing, but distribute the stretching equally throughout the whole length of the cotton, so as not to tear the bands in the operation. For this reason the rollers are put as near to one another as the drawing will allow. As the object of drawing is not to make the slivers finer, they are also "doubled" during this operation, and through continually "doubling" them and "drawing" them out the advantages of making them more even and getting rid of weak places are obtained. In a drawing frame which has three pairs of cylinders and four heads the second pair of rollers have double the velocity of the first, and the third three times that of the second. Consequently, if a sixfold band 1 centimetre long passes through it is drawn out 6 × 6 × 6 × 6 times its length—*i.e.* to a length of 1296 centimetres.

The "drawing frame" represented in transverse section in fig. 8 has three pairs of cylinders of 3 centimetres diameter. To make it more distinct, the head is shown on a larger scale in fig. 9. The lower grooved rollers *d*, *e*, *f*, run through all the heads, and are made to revolve at different rates, by means of an arrangement of toothed wheels. The upper rollers *a*, *b*, *c*, are covered with leather.

THE BUILDING AND THE MACHINE DRAUGHTSMAN.

CHAPTER XVII.

We proceed in fig. 4, Plate CLXXV., to give other illustrations at once of projections and shading of those of various objects in which the circular line in plan is a chief feature. And the first diagram in this illustrates what we have before alluded to in connection with diagram *a b c d* in fig. 1, Plate CLXXV.—namely, that the character of the shading is reversed in the case of a concave or hollow rounded body from that given in the shading of a body convex or cylindrical. Thus, diagram A, to the extreme left, fig. 4, Plate CLXXV., in which the "sectional" plan of a semi-cylinder is given at upper side, showing that it is not solid, but is hollow. This hollow or vacant space in the centre is also semi-cylindrical—that is, its outline is concentric, or its curve parallel to the outside curve. The "elevation" at top, which is in outline, conveys no idea of the exact peculiarity of the object. This, however, is given in lower diagram to the extreme left as well as can be given in a drawing which is in "plane projection" and not in perspective. In this we have the shading reversed in character from that of the cylinder or convex rounded body shaded in *a b c d*, fig. 1, Plate CLXXV. In this latter diagram we have the darker shaded side to the right, while we have it in the hollow body in lower diagram to the extreme left, fig. 4, Plate CLXXV., the lightest shade being to the right in place of the left.

In second diagram, fig. 4, Plate CLXXV., we have in sectional plan the semi-cylinder, as in first diagram; but in this case, in place of the hollow on its under side being semi-cylindrical, and therefore curved in outline, it is square-sided or rectangular. Here the unshaded elevation in the centre is precisely the same as in the centre diagram to the left, the difference between the character of the projection being made evident to the eye only by shading it, as in lower second diagram. In this the dark "shadow" to the left of the hollow part is put in by certain rules hereinafter explained; proceeding, however, on the same assumption as already named, that the light thrown upon any object comes from the left hand, and at a certain angle. The precise difference between the terms "shaded" and "shadow" may be, should space permit, hereafter fully explained in describing the principles of the "projection" of shadows. Meanwhile, suffice it to say that an object is "shaded" when it is so treated by the draughtsman as to indicate flat or rounded or hollow surfaces on parts, as in the diagram we have given in figs. 1 and 4, Plate CLXXV, and fig. 1, Plate CLXXVI. An object or part of an object is said to be in "shadow" when another object or part of an object intervenes or comes between it and the light. Thus, in the sectional plan of a square block, D, fig. 1, Plate CLXXVI., the inside of which is a hollow rectangle, the dark part *a* is the "shadow" thrown by the part *b*, which intervenes between it and the light which is supposed to come from the left-hand side of *b*. The same shadow is shown at *c c*, in the elevation of the object in *a b*. In like manner *a*, in diagram B, fig. 1, Plate CLXXVI., is the "shadow" cast upon the part *b* by the projecting part *c*, which intervenes between it and the light, coming in the direction and at the angle of 45° at *d*, this being the angle assumed in the projection of shadows.

Returning to the diagrams in fig. 4, Plate CLXXV., we here, in second diagram to the left at bottom, see the shadow in the elevation, as thrown by the projecting part at the side of the hollow In third diagram from the left, in the same figure, the semi-cylinder has the hollow part in its under side in the form of a triangle. Here, again, the only difference in the appearance of the projection between it and the first and second projections is the centre line which is the projection of the line at central point of upper figure. It is only when shaded that the eye takes in a conception of what the character of the object is, as shown in elevation. The same feature is further illustrated in the fourth diagram from the left, at top, in which the elevation of the object is precisely the same as the elevation of object in third diagram, and it gives no indication of the fact that the triangular part in fifth diagram projects from the semi-cylinder in place of receding into it, as in third diagram. And it is only when the elevation, fifth diagram, is shaded, that the reader has a conception of what the character of the object is which it represents as graphically as "plane projection" can present it. By certain methods of projection popularly known as perspective, objects can be shown more graphically than by plane projection, although those methods are not so practically and widely available as this latter system of projection, which is that universally employed in and for the preparation of "working drawings."

The diagram in fig. 4, Plate CLXXV., represents projections of objects the external diameter of the plan of which, as looked at in the direction of top, is the same in all—namely, a rounded surface—semi-cylindrical. But the difference between the projections in the last three diagrams and the first three diagrams is that in the last three the under sides have parts projecting from the flat, while in the first three the parts recede into the body of the object or give hollow parts. And the youthful draughtsman will receive a practical lesson if he studies the peculiarities of each in relation to what we have given already as to the value of shading in showing the characteristics of objects which without it would present the same appearance to the eye where the projections are given in pure outline; although the characteristics of the various objects are so essentially different. This is further and practically illustrated by fourth and fifth diagrams, which give in the projections of the elevations precisely the same appearance to the eye as the projections in first and second diagrams; and this although the points in fourth and fifth diagrams project from, while the points in first and second diagram recede into the body of the object projected. And it is only by shading, as in fourth and fifth diagrams, that the difference between these projections and those in first and second diagrams is grasped by the mind of the spectator. This is again illustrated in third and sixth diagrams, in which the projections of elevation are precisely the same in appearance, although the characteristics of the two objects are so essentially different, and it is only when they are shaded as in lower diagrams that the difference can be understood.

But the reader must be careful to note that while shading possesses great practical advantages, as affording a means of more readily distinguishing between different parts—for example, between those which have a flat and those having a rounded surface, between parts projecting and parts receding—shading is not essential in "plane projection." In practice, indeed, especially in engineering working drawings—that is, the drawings actually given out to the workmen from which the measurements are taken in constructing the objects projected or drawn—shading is not resorted to, only in a few and exceptional cases. It is only in what may be called "office drawings"—that is, those which are kept for reference or for business purposes, to show to clients and customers—that shading is systematically resorted to and carefully executed. And this, if for no other reason than to make the drawings look more attractive, as well as to convey a better notion of what the peculiarities of the objects represented by the projection are to clients, many of whom, having no practical knowledge of drawings executed in plane projection, have often a great difficulty to understand the nature of the parts of an object shown, especially if those be unshaded. Notwithstanding that shading is not essential to the practice of plane projection, all the views of objects obtained by which can be at once grasped by the mind of the draughtsman, who knows what its principles are, still a knowledge of shading and of the projection of shadows is necessary to the draughtsman. Much of the practical part of this department we have already illustrated, and by this enough will have been conveyed to the intelligent reader to enable him to shade a large proportion of the parts of objects he projects or draws.

Further illustrations of the methods of "shading" plane projections will now be explained in order to make our present department complete, which, although, as we have shown, but limited, is still sufficiently wide in its scope to afford information applicable to a pretty wide range of practice. So wide, in fact, that if the reader be careful to study closely what we have said, and to examine carefully the diagrams by which this is illustrated, he will know enough of shading to suffice for the practical requirements of ordinary practice. We have hitherto shown how views of objects in plane projection—that is, in pure outline on perfectly flat surfaces—have their parts so shaded that hollow parts have a different surface or appearance given to them from those which are not hollow; by this means giving that distinctive character to the view of the object which would be lacking if it were done in pure outline only. We have seen that this effect is produced by giving to the surface different tints or tones at different parts, those tones or tints being produced by "colour" in the actual practice of preparing drawings of architectural and engineering objects, or by means of pen or pencil by lines and dark parts as shown in the various diagrams we have given.

But in many cases the drawings or projections are given in the actual work of the drawing office in pure outline, colour or shading being wholly wanting. To show, however, the distinction between hollow and projecting parts, a method is adopted in finishing the drawings which gives this distinctiveness to a large extent. This method is known as "shade lines." We have seen, in describing diagram D in fig. 1, Plate CLXXVI., that the "shadow" of an object or part of an object is cast—to use the popular term—or projected on the surface on which the object is lying or standing, or against which it may be placed; the light being supposed to come from the left-hand side at an angle of 45°, as in the direction of the arrow *d* in the diagram D in fig. 1, Plate CLXXVI., and from the top in the direction of the arrow *e*. The result of those two directions in which the light is projected upon an object is that its shadow is a compound, so to say, of those two directions—showing us partly to the right hand side of the object, and partly on its under side—as shown at the part in shadow at *a*. When there is only a side projection, as in the direction of the line *f g*, the shadow cast or projected is at one side, but as shown in the triangle *f g h*; the corresponding projection of shadow in the plan being at *h i*.

THE GEOMETRICAL DRAUGHTSMAN.

HIS WORK IN THE CONSTRUCTION OF THE FIGURES AND PROBLEMS OF PLANE GEOMETRY, USEFUL IN TECHNICAL WORK.

CHAPTER X.

THROUGH one of the ends, A, of the straight line, A B, fig. 50 (last chapter, p. 93), let us draw any straight line whatever, A X; upon this line let us carry A M = *m* M N = *n*, M N = *n*; let us join N B and lead M C parallel to N B; we shall have—

$$\frac{AC}{CB} = \frac{AM}{MN} = \frac{m}{n}.$$

To draw a Line which will be a Fourth Proportional to Three given Straight Lines, *m*, *n*, *p*.

That is to say, to construct a line, *x*, so that it may have the proportion $\frac{m}{n} = \frac{p}{x}$; otherwise expressed, to construct the fourth term of a proportion of which *m*, *n*, and *p* are the first three terms, and which are arranged in the order indicated. First construction. —Draw two straight lines, A D, fig. 51, and A E, making between them any angle whatever, upon one of which take A B = *m*, fig. 50, B D = *p*, on the other A C = *n*. Join the point B to the point C, and, through the point D lead a line, D E, parallel to B C. The line C E is the line in fourth proportion required.

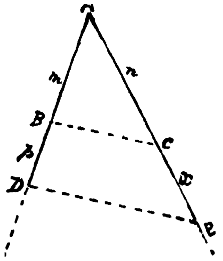


Fig. 51.

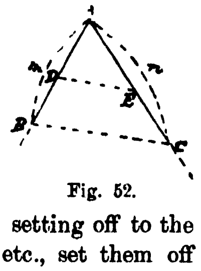


Fig. 52.

But in place of setting off to the end of both lines the length *m* *p*, etc., set them off at starting from the point A, fig. 52, and take A B = *m*, A D = *p*, A C = *n*; this would then be the line A E, which would be the line wanted. This problem, founded upon the same theory as the preceding, takes up less space in its construction.

The arrangement of the lines, *m*, *n*, and *p*, might also be varied in the same construction. Thus draw two parallel lines A C and A′ C′, fig. 53; upon one of them (see the first figure, 50) we take lengths A B = *m*, B C = *n*; upon the other we take a length A′ B′ = *p*. We join A A′ and B B′ by two straight lines which meet at the point O. We join the point O to the point C, and the line O C′ cuts at C the line A′ B′

We have $\frac{AB}{BC} = \frac{A'B'}{B'C'}$ or $\frac{m}{n} = \frac{p}{B'C'}$; and the line B′ C′ is then the fourth proportional wanted.

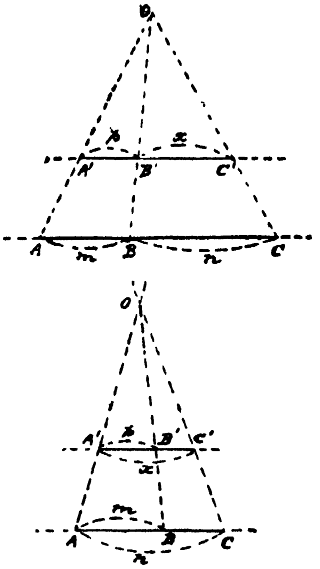


Fig. 53.

The construction may be still varied without changing the principle; this is shown in the second diagram in fig. 53, which it is unnecessary to explain in detail.

To draw a Third Proportional to Two given Straight Lines, *m* and *n*, fig. 54; that is to say, the Fourth Term of the Proportion $\frac{m}{n} = \frac{n}{x}$.

This problem may be taken with the preceding problem, making of it $p = n$; but we will, however, give as example several constructions. First, on the line A B = *m*, fig. 54, as diameter, describe a semicircle; starting from the point A draw a chord, A C = *n*; and drop upon A B a perpendicular C D. The line required is equal to A D. The chord A C is mean proportional between the diameter A B and its projection A D. On this diameter we have then—

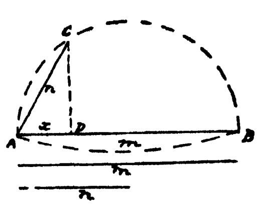


Fig. 54.

$$AC^2 = AB; \; AD \text{ or } n^2 = m\,AD; \text{ or again, } \frac{m}{n} = \frac{n}{AD}.$$

In the second construction draw two rectangular lines, A C and A B, fig. 55; on these two lines take A B = m, fig. 54, and A C = n, and join B C, and at the point C let us lead C D perpendicular to B C. The line A D is the line required. We have thus—

$$\overline{\text{A C}}^2 = \text{A B} \cdot \text{A D} \text{ or } n^2 = m\,\text{A} \cdot \text{D}; \text{ or } \frac{m}{n} = \frac{n}{\text{A D}}.$$

In the third construction describe a circle with any

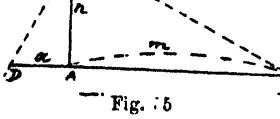


Fig. 55

convenient radius, and draw to it a tangent A C = n, fig. 56, from the point A as centre, with a radius equal to m; describe an arc of circle which cuts the circle at B; join A B.

This line meets the circle at D, and we have A D = x, for the tangent, A C being mean proportional between the entire secant A B and its outer part A D. We have thus $\frac{\text{A B}}{\text{A C}} = \frac{\text{A C}}{\text{A D}}$, or $\frac{m}{n} = \frac{n}{\text{A D}}$.

To draw the Mean Proportional between Two given Straight Lines *m* and *n* (fig. 54).

In the first construction, upon a straight line A C set off two lengths, A D = n, A B = m; on the length

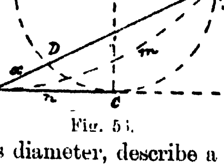


Fig. 56.

A B = $m + n$, as diameter, describe a semicircle. At the point D raise a perpendicular to the line A B, which meets the circle at D. We then have $\overline{\text{D C}}^2 = \text{D C} \cdot \text{A D} = m\,n$; and A C is then the mean proportional wanted. In the second construction, on the longest, m, of the

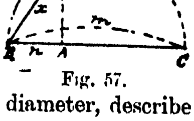


Fig. 57.

two given lines as diameter, describe a semicircle B D C (fig. 57); let us take a length B A = n; at the point A raise a perpendicular A D. This perpendicular meets the circle at D; let us join B D; this is the mean proportional wanted, for we have $\overline{\text{B D}} = \text{B C} \cdot \text{B A} = m, n$.

To divide a Straight Line I (fig. 58) into Two Parts which are One to the Other as Two given Squares *C* and *C'*.

First find two straight lines which are one to the other as the squares C and C′; we can then divide the given straight line into two parts, which are one to the other as these two straight lines. Make a right angle Y O X; take O A = c and O A′ = c', c and c' being the sides of the given squares. Join A A′, and from the point O drop O P perpendicular on this line. The triangle A O A′ being a rectangle, we shall have

$$\frac{\text{A P}}{\text{P A}'} = \frac{c^2}{c'^2} = \frac{\text{C}}{\text{C}'}.$$

It only remains to divide the line C into parts which are one to the other as the lines A P and P A′, as

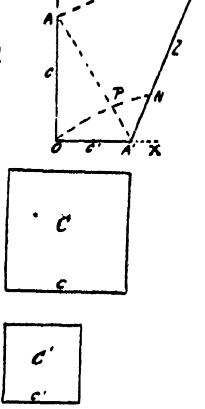


Fig. 58.

described in problem fig. 50. Next draw any straight line A′ R, upon which we take A′ L = l; let us join A L, and through the point P let us lead P N parallel to A L; we shall then have $\frac{\text{N L}}{\text{A}'\text{N}} = \frac{\text{A P}}{\text{P A}'} = \frac{\text{C}}{\text{C}'}$. The point N divides then the length C in the ratio stated in the title to this problem.

To divide a given Straight Line *A B* (fig. 59) in Mean and Extreme Proportional (that is to say, in Two Segments, such that the Greater may be the Mean Proportional between the Smaller and the Whole of the Straight Line).

This expression, says an able Continental geometrician, to divide in mean and extreme proportional,

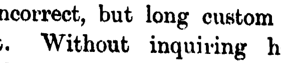


Fig. 59.

is evidently incorrect, but long custom or usage has sanctioned it. Without inquiring here by what course of alterations of text or corruptions of language it has been introduced into science, we will try to make its meaning clear to beginners.

THE CARPENTER AND HIS TECHNICAL WORK

ITS ORIGIN AND EARLY PROGRESS—THE PRINCIPLES AND DETAILS OF ITS PRACTICE.

CHAPTER XIV.

FIG. 10, p. 13, vol. i., and fig. 1, Plate XIX., illustrate the system of joining timber together by what is called "scarfing," the joint *a b*, fig. 10, p. 13, vol. i., being at an angle or oblique to the faces of beam to be joined. The joint is technically called a "table," and some forms of scarf joints (they are pretty numerous) have several tables: see fig. 3, Plate XIX. The two beams are secured at the joint by bolts and nuts, or by "shrunk-on" hoops of iron. To make the joint still more secure, in some modes of scarfing, keys of hard wood are driven into apertures cut in the tables of the scarf—one-half being in one, the other in second half of beam. This is illustrated in *c* and *d*, either as at *d* in the centre or as at *c* in the corner of the scarf, fig. 4, Plate XIX. Fig. 9, p. 13, vol. i., illustrates a mode of scarfing when the tables are parallel to the faces of beams.

In fig. 3, Plate XIX., *a a* is the lower, *b b* the upper beam; the ends of each being cut so as to give an irregular or oblique "table," as *d d*, finished off at the ends obliquely as shown. The two are secured together by bolts and nuts. The lower diagram, B, shows the two pieces separated and in section; the letters of reference accented being the same as in the upper diagram. In this the single table of the method illustrated in fig. 10, p. 13, vol. i., is represented by a series of tables as *d d*, *e e*; these alternately projecting as *d d'* in the section in diagram B, and recessed as at *e e'*, interlock, so to say, with one another, and thus prevent movement under pressure. The two are secured together by bolts and nuts, or by straps. The diagrams in fig. 4, Plate XIX., show a method sometimes adopted in this form of scarf-joint, a key, as *c*, being placed at the corner of the projecting point of the table *b* on beam *a a*. Keys are sometimes put in the flat part of tables of scarf-joints, as at *d* in beam *e e*, in diagram C, same figure. This method of keying may also be applied to the scarf-joint in fig. 70, as at the centre of the tables *b*, *b'*, or at the ends, as *e*, *e'*. In this figure the upper diagram is elevation, showing method of securing the two beams together by bolts and nuts *c c*, *d d*; the lower diagram shows the two separate and in section.

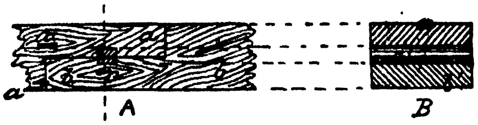
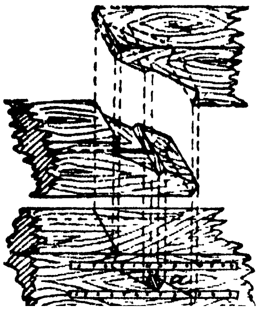


Fig. 71.

Fig 11, p. 13, vol. i., upper diagram, illustrates a form of scarf-joint in which a horizontal table, as *a a*, is used with an oblique one at *b b*. A key, *c*, being put in at their point of junction, the two are secured together by bolts and nuts, *d d*, *e e*. The lower diagram is section with beams separated.

Concluding Remarks on Scarfing or Lengthening of Beams.

In the preceding paragraphs we gave descriptions and illustrations of different methods of lengthening beams,—that is, of making one long beam out of two short ones,—those being known as fishing and scarfing, the latter being the more generally employed. We now proceed to describe the methods employed for adding to the strength of beams, so as to enable them to carry heavier weights or sustain greater pressures than those the strength due to their natural or given dimensions enables them to resist or bear. But before giving our illustrations of these methods, it will be well to add to what we have already said in last chapter, on the subject of lengthening beams by fishing or scarfing, the following considerations. By giving the "tables" or bearing surfaces of the joints, and adding the bolts and nuts or straps by which the pieces are bound, the two pieces of wood joined in this manner are as solid as one piece of the same size made out of a single piece, provided always that the strain is given only in the direction of the length of the piece, because the joint is arranged in such a way as to resist a force of tension or pulling rather than a strain of cross or tranverse pressure. The surfaces of the tables are generally cut obliquely, and the cuts are kept together by a strong square oaken peg, which should press the faces firmly together. The pieces of the joint are united or held together by means of iron hoops, or, as we have already shown, by bolts and nuts. Generally these hoops or bands are made to go round and embrace the beams completely; sometimes in place of encircling hoops the bands are confined to plates or strips, which are placed on each side of the beam, as shown in fig. 72; *a* the iron plate or band, bolted to the beam. This is sometimes let into the beam or, as more generally adopted, simply laid on the



surface. There may be two, or even three of these plates, in the depth or side of the beam; and in addition top or bottom plates may be used, as illustrated in fig. 73. In place of plain-surfaced "tables," or skewed or oblique surfaces being used in scarfing, as in fig. 10, p. 13, vol. i., the faces of the tables are cut up into tenons and mortises as in fig. 3, Plate XIX., or fig. 11, p. 13, but this is only done in special cases. The first quality of a joint is great accuracy of fitting of the surface, and it is very difficult to cut quite exactly pieces so complicated. Generally the form of scarf-joint used is that with two inclined faces, as in fig. 10, p. 13, vol. i., taking care always to add hoops or bands of iron, as shown, or bolts and nuts as in fig. 9, p. 13, vol. i.

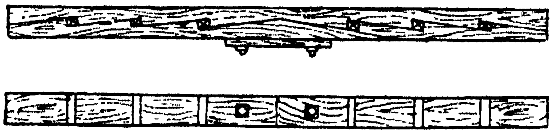


Fig. 73.

When the pieces are intended to be placed vertically, they are joined by tenons and mortises, as shown in fig. 32, p. 191; and see pp. 138-9, 191, 265-6.

We have now shown in succession the principal joints used in carpentry. Custom will teach us how to modify their proportions according to the work that is to be executed, and with due regard to the quality of the wood employed.

In executing joints we should never deviate from the rule which enjoins that the projections formed by the grooves and sections at the end of one piece that is to be joined into another shall be according to the grain of the wood and without interruption, in order that no splinter may break away. Dovetailed joints, and the form of scarf as in fig. 4, Plate XIX., are exceptions to this rule; but we may rest assured that their length and the inclination of their sections are such that there can be no reason to fear the breaking off of any of their parts. A second rule which ought to be adhered to is that the divisions and grooves cut out to receive the joints must not have any part of the same kind weaker than the others, since they must all resist pressure equally.

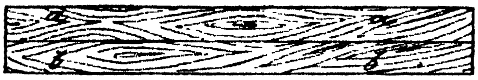


Fig. 74.

The Strengthening of Beams.

We now turn our attention to the methods of strengthening beams, the first we take up coming under the term or designation of "built beams."

When we wish to increase the strength of a beam which, besides its own weight, has to support a load too heavy for its natural section or dimensions, we have recourse to different methods which we are now going to point out.

We might at first rest satisfied by placing a second beam by the side of a beam which is too weak, and thus sharing the weight between the two; but, in this case, the resistance of the two beams would be simply equal to the amount of the resistance of each. If, on the contrary, the pieces are united by well arranged and secured joints, or if they are bound together by bolts or hoops, in such a way that from their union may be obtained a solid body, all the parts of which shall be conjointly liable, so as to remain in juxtaposition at the time of bending without the possibility of slipping one against the other, we shall obtain a great increase of strength.

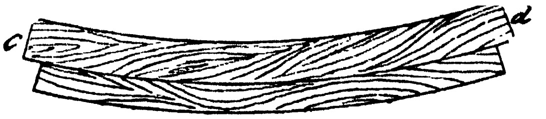


Fig. 75.

To obtain the result which we have just pointed out, we join pieces of wood in the form as shown in fig. 76; but we must remark that the arrangement of the grooves is very important relatively to the effect which they are to produce. If we have two pieces of wood superposed one upon another, as the beam *a a* upon *b b* (fig. 74), not fastened together, and surmounted by a weight placed in the middle, this load will make them bend, as in *c d* (fig. 75); thus the points of the upper piece will have slipped over the under piece. It is this slipping which must be prevented by means of a joint, so as to give points of resistance, and we obtain this by making grooves like those represented from *f* to *g* (fig. 76), and by securing the two pieces together by means of bolts. By this arrangement the bolts are subjected to very little strain. It is easy to understand that if the grooves were made the contrary way, as in fig. 77, they would have no effect; we must therefore, before fixing their position, take into account the amount of strain which they will have to resist.

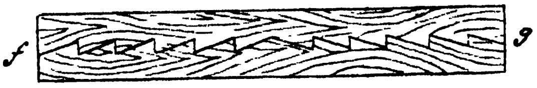


Fig. 76.

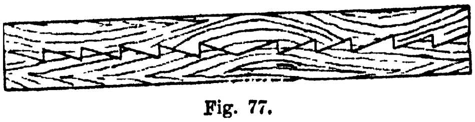


Fig. 77.

Practically it would be very difficult to make the grooves, such as we have just pointed out, with such precision that there shall be no space left between the faces of the grooves.

THE FARMER AS A TECHNICAL WORKMAN.

HIS TOOLS, IMPLEMENTS, MACHINES AND MATERIALS. —THE PRINCIPLES OF HIS WORK IN ITS VARIOUS DEPARTMENTS.

CHAPTER VII.

AT conclusion of preceding chapter we referred to the importance of having soils in good condition, fitted for the growing of crops, that condition referring chiefly to their divided or open and friable state. We shall see further on how the opening up of our soils to all the plant fostering and furthering influences affects the future of farming, and how closely it concerns the application of steam power to the preparation of soils for seed-beds, of which new power we shall have yet somewhat to say.

On the other hand, it is admitted on all hands, both by scientific and practical men, that fertilising substances thus absorbed by the soil are given out, so to say, or are best separated or taken from them, by the action of the rootlets of plants, these having a far higher power of assimilation than water, or, indeed, any known agency. From this is deduced the practical fact that the greater the facilities we give to the rootlets of our plants for penetrating the soil, the greater is the supply of fertilising matter we give to them. Now, it is also obvious beyond a doubt that rootlets of plants will penetrate a soil the particles of which are loose and friable with much greater ease than when these particles are impacted, forming a hard mass more or less solid. And, as if to aid in this direction, it is a curious and a fortunate thing that the powers of plant rootlets to extend themselves far into the soil in search of food is very great; and it is a singular point worth noticing here, and one not altogether without its practical bearing on the subject, that this power is developed in a different way in different plants according to their necessities, some having a tendency to send their roots deep down in a vertical direction, others in a lateral direction. A plant, or rather its rootlets, by which it draws to the main plant growing in the atmosphere the fertilising constituents contained in the soil, may be familiarly likened to a cow feeding in a pasture-field. As the cow eats up the at first abundant grass at one part, exhausting its supply of food, it moves on to another; but the cow would starve if it remained in one spot, seeing that if it did not go to the parts where there was plenty of grass, these fertile spots could not go to it. This appears to be an absurd, or, as some would say, a silly way of stating a self-evident fact; it is not so, however, but conveys a lesson of the utmost value to the practical man. For how is it that, although it is just as evident that the rootlets of the plant must go in search of its food present in the soil, the soil possessed of these not going to it, so little attention is paid by many farmers to the condition of the soil giving facilities for the rootlets of the plant they grow to go to those parts of it in which their food is present? Nay, we may further ask, how is it that, so far from giving this loose condition to the soil in which it is possible, to say the least, for plants to penetrate it, many farmers carry out from year to year methods of cultivation which of necessity create, or have a tendency to create, that very state of the soil through which it is impossible for the plants to penetrate at all?

Influence of the Mechanical Condition of the Soil on the Absorbing Power of Plant Rootlets.—Pulverisation of the Soil.—Tilth and Plant Rootlets.

We shall see, when we come to investigate the action of the plough, in explaining its construction, how a method of working it actually produces this very condition of the soil, by the creation of what is technically called the "pan." This, by the continued action of the plough, season after season, gets so hard set and compressed that it virtually limits the depth of root penetration. And this depth, beyond all doubt, is far within the limits to which even those plants which have the least development of vertical root growth naturally would go. The further we go, indeed, into the practical points of farming, the more we shall find the dependence of one process and result upon another—forming a chain, so to say, of which it is dangerous to destroy or weaken a single link.

This point of pulverisation or porosity of the soil, through mechanical as well as atmospheric pulverisation, is one, therefore, of the utmost practical importance, claiming to receive, what it has not generally amongst farmers received, that degree of attention which is its due. Let it be remembered also, as one of the features of this point, that a condition of the soil which prevents the rootlets of a plant penetrating the soil to the utmost extent of its root development—each plant has got its own measure or natural length of rootlets—acts mischievously in two ways. First, by depriving it of fertilising constituents which it would obtain if its rootlets could reach them; and, second, by exhausting the power of the plant through its very endeavours to penetrate the hard, unyielding soil. All rootlets are extended or grow by the formation of a number of cells, each of which is produced at the extremity of the rootlet. If a rootlet, therefore, or properly speaking a cell, penetrates the soil, it is obvious that it must exert a force superior to the cohesive power of the soil—or, in other words, must exercise a greater power than the soil possesses to resist penetration. So much of the inherently vital force of the rootlet must therefore have been exhausted by its efforts to penetrate a soil which offers a certain resistance to penetration. This force or vital energy of the rootlet may be such that it may penetrate the soil, but this may be so exhausted that it cannot extend far beyond; while it may be so far short of the power necessary to penetrate the barrier that it cannot do so at all, stopping short of the obstacle; or it may penetrate it, but be able to do no more. Any one who has studied closely the phenomena of plant growth and culture must have noticed, amidst the curious and highly interesting facts which observation shows, how a rootlet is stopped in its development by some obstacle in its way, while another keeps on penetrating the soil.

Stirring of the Soil.—Deep Culture.—What it Involves.

This point, here dwelt upon at some length, is, as we have said, of the utmost practical importance; we should not, indeed, be far wrong if we said that it lies at the very root of the question which affects the future increase of the fertility of the soil of this country. For that it can be even greatly increased is a position in which there is a general consensus of opinion amongst scientific and thoroughly practical men. We shall have occasion, in describing steam cultivating mechanism, in the series of papers entitled "The Agricultural Implement Maker," to draw attention to the subject of deep cultivation—or, to put it more correctly, deep stirring of the soil—and to show the great power which steam culture gives to the farmer to increase the fertility of his soils. And it is just in relation to the office which the rootlets of plants perform, that deep stirring of the soil by steam power offers such great practical service. But it is right here to note that we use the words "deep stirring" of the soil with predetermined purpose, order in to denote that it is quite a different operation from that to which the name of "deep culture" has been given. As a rule, the latter term involves in the minds of most men the idea of first stirring the deep-seated soil—or subsoil, as it is termed, as it normally lies under the soil which is usually worked—and thereafter bringing it up to, so as to be mixed with the soil of the upper surface. Now, "deep stirring" of the soil may include this latter point; but it also includes the stirring of the soil *in situ*, or its natural position—that is, merely adding to its porosity where it lies, not bringing it at all to the surface—although, as said above, this primary operation may be carried a stage further, to the secondary one of bringing it up and mixing it with the ordinary or surface soil. But, as all practical men know, this mixing of it is frequently productive of mischievous results—often so mischievous that they have created a strong prejudice in the minds of farmers against having anything to do with methods which propose to touch the sub- or deep-lying soil at all. Such men have yet to learn that deep "stirring" of the soil does not of necessity involve any bringing of it to the surface, and that it offers, besides other advantages yet to be noticed, the great one of enabling the rootlets of plants to penetrate the soil. Such men have also yet to learn much, if not all, of what this soil-penetrating power of plants involves. There is no absolute necessity to bring deep-stirred soil to the surface—an operation which many practical men look upon with dread, and which it is only right to say, if done at all must be done thoughtfully, with the greatest caution. One of the most practical of our cultivators, who has had more experience in land culture than most men, states that if any sub- or underlying soil be "properly loosened" or made porous throughout, there is no necessity to bring it to the surface at all. And he is right; for, apart from the other advantages flowing from this system of culture, it puts the soil in the best condition to enable the rootlets of the plants to penetrate it.

The Condition of the Soil in Relation to certain of its Fertilising Inorganic Constituents.

We have still further to point out that of the inorganic substances in the soil, some require to be placed for a long time under the atmospheric influences before they can be put in a condition, so to say, in which they can be made valuable for the food of plants; but it is also noticeable that this change is much more rapidly brought about when the soil is in a good mechanical condition—that is, loose and friable—than when it is in the opposite condition. Now, it so happens that the most active agent in thus quickly changing the condition of these inorganic constituents from an inert to an active condition, is that which is brought most quickly and favourably into play when the soil is in this open condition. But this open condition brings into favourable operation causes which add greatly to the fertility of the soil other than those already named—such as the influence of the atmospheric heat on the surface of the soil where it is beneficial, the evaporation of stagnant water, the deposition of dews, and the rapid and healthy germination of seeds.

Influence of the Condition of the Soil in the Germination of the Seeds of Plants.—Practical Importance of this Point.

The last-named point, the influence which a soil in a good mechanical condition (that is, porous or pulverised) exercises upon the germination of the seed, is one of great—indeed, seeing that the seed is the germ or point from which all succeeding results flow, or from which the various processes start, it may be said to be of the greatest—importance. It is necessary to glance at what constitutes the conditions of the question. These are often overlooked, but it is difficult to overestimate the weight or extent of the influence which a right understanding of them has upon the questions connected with the design and construction of mechanical aids to soil preparation.

THE STONE MASON AS A TECHNICAL WORKER.

THE PRINCIPLES AND PRACTICE OF, AND THE MATERIALS HE EMPLOYS IN, HIS WORK.

CHAPTER XIII.

Arch Mouldings *(continued).*

FIG. 84 is section one-fourth full size—three inches to the foot—of another set of mouldings from an arched doorway, fig. 85 being part elevation of the same.

The Stonework of Windows chiefly in the Gothic Style—Mullions—Window Heads, Side or Quoin Dressings, etc.

In many forms of windows, especially in one or other of the varieties of the Gothic as applied to domestic architecture, the window "void" is filled up with moulded astragals, so as to divide the space into two, three, or four equal divisions or "lights," according to the width of window opening, each division having its own window framing for glass. In the Gothic styles the window "voids" or openings are provided with stone dressings placed "quoin" fashion in "longs and shorts," as in fig. 26—or shown in fig. 86—which is the lower right-hand corner of a window in "Domestic Gothic" style, divided into four divisions by a central vertical bar, or astragal, *a a*, and a horizontal bar, part of which is shown at *b*, in fig. 1, Plate III. The junction of the four bars is shown in the diagram to the left of *b*. This fig. 1, Plate III., is part elevation of the upper part of window, to the right hand. In fig. 1, Plate III., the window head, or moulded part which runs along the top, and is returned for some distance down each side is shown, fig. 3, Plate III., being a vertical section.

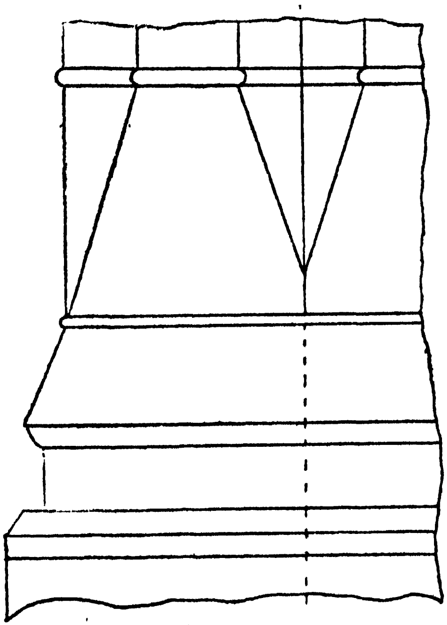


Fig. 79.

Fig. 2, Plate III., is the drip termination of a window head in the "Domestic Gothic" style, a section being given in the upper part of the figure. In fig. 87 we give a drawing showing elevation of junction of horizontal and vertical bars—to an enlarged scale—fig. 88 showing junction of upper end of vertical bar with the centre of the window head, part of which is in elevation on fig. 1, Plate III.

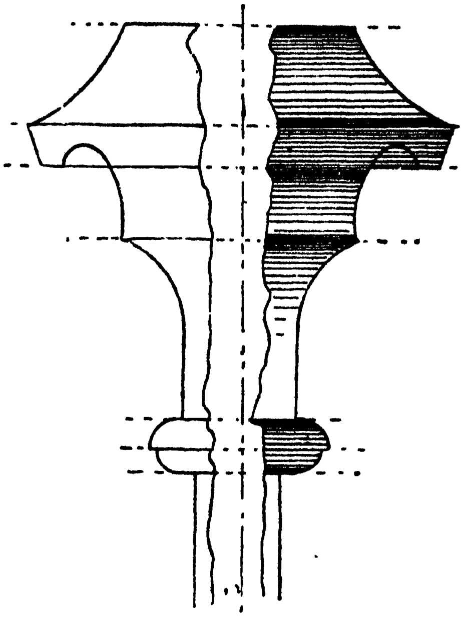


Fig. 80.

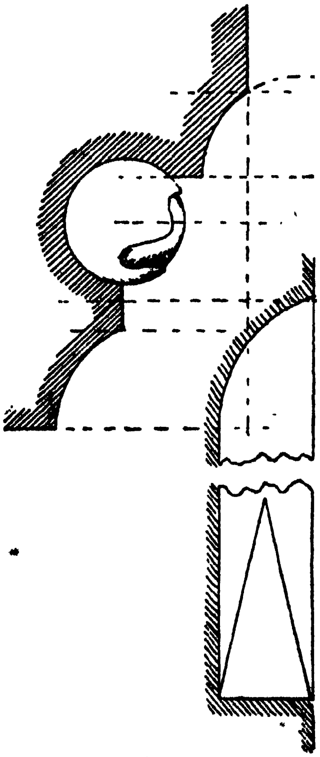


Fig. 81.

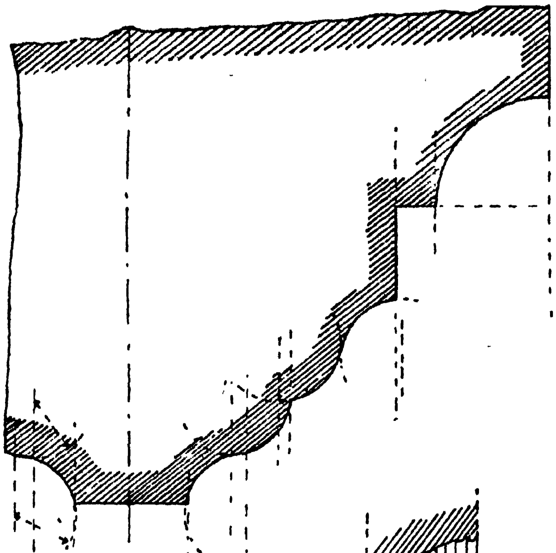


Fig. 83.

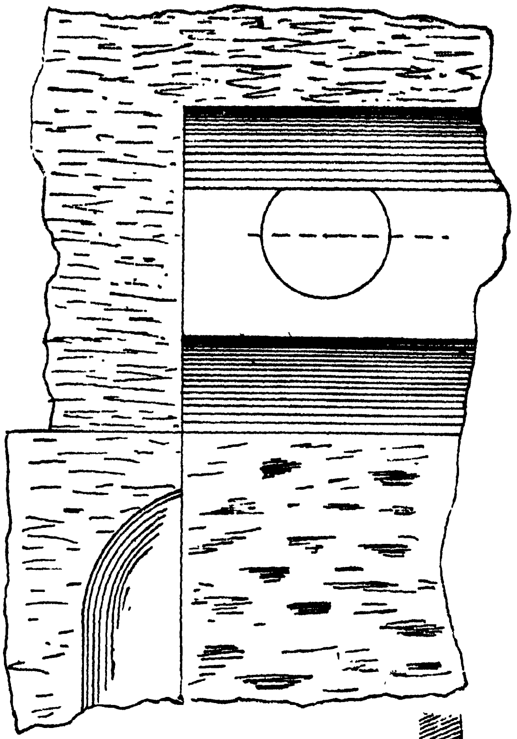


Fig. 82.

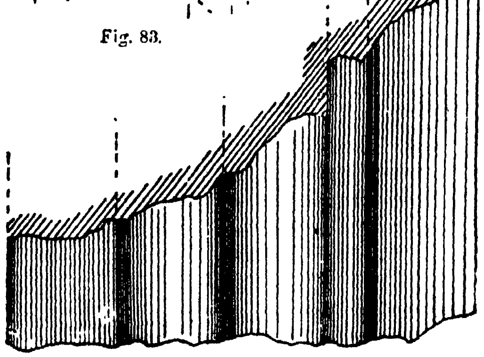
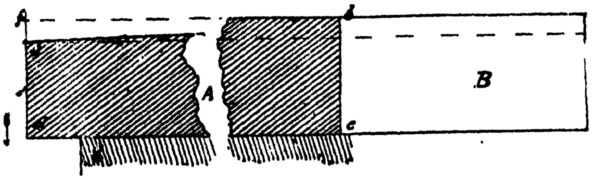


Fig. 84.



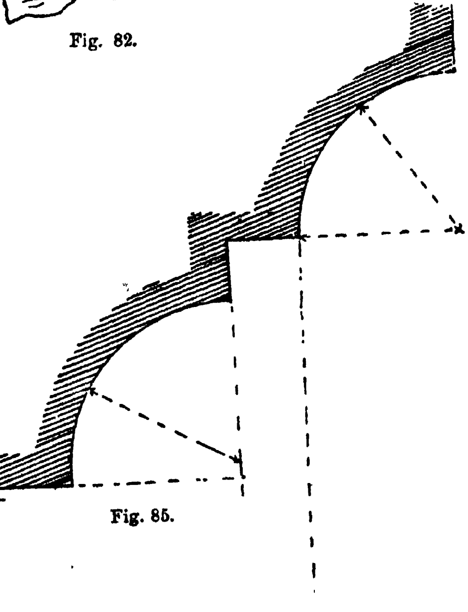


Fig. 85.

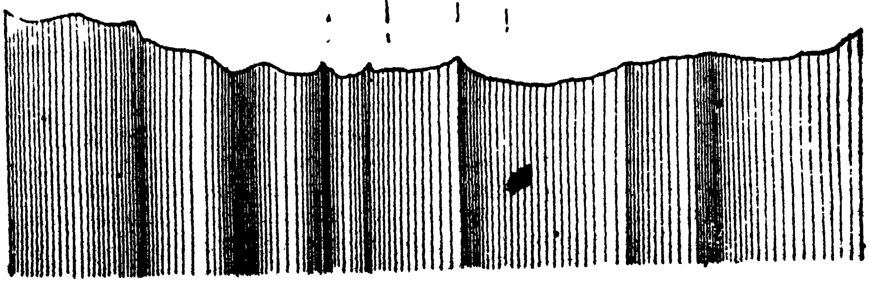


Fig. 86.

THE BRICKLAYER OR BRICKSETTER.

THE PRINCIPLES AND PRACTICAL DETAILS OF HIS WORK.

CHAPTER X.

FOURTEEN inch, or brick-and-a-half, as named at end of preceding chapter, is the thickness generally adopted in the better class of work. All walls are, as already stated, erected in a series of layers of " bricks on bed," each layer being termed a course. However high the wall, there are only two kinds or classes of courses; these being repeated alternately from bottom to top of wall till it is completed. The lowest course, or that which rests upon the ground, is called the " first course," the next above it the " second course "; and, as just now said, these are repeated alternately throughout the whole height of wall.

Foundation or Lower Courses of Walls.

We have said that the first course rests upon the ground; but this is never the case, except in exceedingly poor work, or in cases where the foundation is exceptionally dry and firm, as in the case of rock, which being " benched out "—that is, cut into terrace-shaped parts in order to secure the proper level—the walls may start at once from the rocky surface. But in nine cases out of ten the soil or site upon which a wall is built is of such a nature that special foundations require to be made, upon which the superstructure rests or is built. The lower part of the wall is so formed as to be part of the foundation, and is made much wider or thicker from interior to exterior surface, in order to secure a good broad bearing surface, to resist the weight or pressure of the upper wall. This increased width or thickness is obtained by a series of step-like projections, termed " offsets," as shown in the diagram in fig. 14, at *a*, *a*, *a*. These are, of course, of depth equal to a course of brickwork, and generally of such a width as to project a distance equal to half a brick, or sometimes a quarter of a brick. This latter is, however, too narrow, and should not be adopted, the object being to spread out the foundation so as to have as wide a " bearing surface " as possible. (On the extreme value of a good bearing surface for all heavy superstructures to rest upon, some remarks will be found in the series of papers entitled " The Stone Mason.") Part of the upper wall is shown at *b b*, and the line *c* separating this from the lower part—which is termed the " footing " or " footings " of the wall—indicates the point at which the " damp-proof course " (see " The Sanitary Architect " and " Stone Mason ") is built in, being a little above the ground level. The joists or flooring beams of the floor—supposing the wall is that of a house—are in inferior work made to rest upon the upper surface of the " offset " or projecting part nearest the surface of the ground, as at *a'*; but in superior work it is the custom to rest the timber joists upon small piers of brickwork which are made at intervals along the footings corresponding to the distance between the joists.

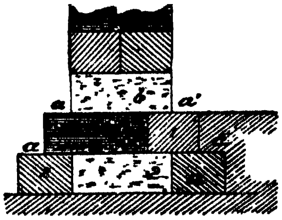


Fig. 14.

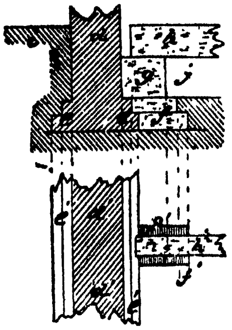


Fig. 15.

Piers or Bearing Walls for Joists at Foundation Courses.

The method of forming those piers or bearing walls for timber joists is illustrated in fig. 15, in which *a a* is supposed to be vertical section of part of the outside wall, with its footings *e* as at *a a* in diagram fig. 14. The footings *e* are carried out at intervals—as at *f* and *f*, in plan—along the length of wall, corresponding to the distance between the timbers to be supported, as in the case of " girders " and " binding joists " (see " The Carpenter "), or carried along the whole length of walls on the sides at which the joists terminate. Those footings carry the piers, or bearing wall *g*, in plan *g'*, which projects sufficiently far from the wall *d* as to give a good length of bearing—say nine inches to the end of the joist or beam *h*. The upper surface should be some distance above the

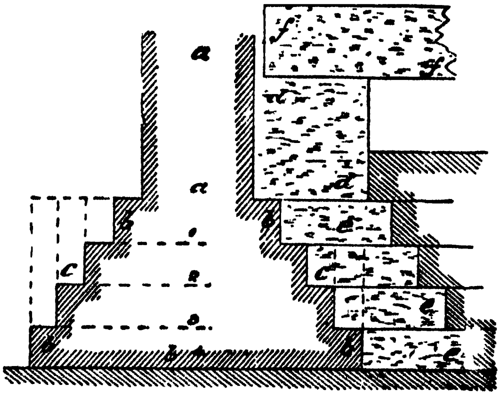


Fig. 16.

ground level *i*, so as to throw the boarding floor above the ground—and afford a clear, dry, vacant space, as *j*, below the joists and flooring. Two steps—three or four are better—from ground level *i* to level of floor of lobby of house will give the height desired of floor surface above that of external ground, and thus secure a dry foundation (see "The Sanitary Architect"). In fig. 16 we give the section of a thicker wall, *a a*, than in diagram *a a b* in fig. 15, with deeper and wider footings, *b b*, the offsets, as *c c*, being four in number. The lines of bearing wall *d d*, or of piers, are shown at *e e*; *f f* being part of a girder or binding joist.

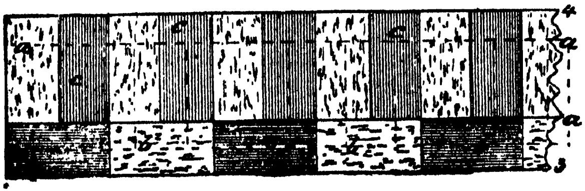


Fig. 17.

"Footings" or Foundation Courses of a Nine-Inch or One-Brick Wall, with different "Offsets" or Courses.

In fig. 17 we give the plan of "footing" for a "nine-inch" wall—that is, one brick length in thickness—which is that of the upper wall borne by, or resting upon, the footing shown in the drawing. The first course of this nine-inch wall is shown by the dotted line *a a*. The "footing" course is made up of a line of "stretchers," *b b b*, with a set of "headers," *c c*, behind—at right angles to them—thus making a course equal to a brick and a half in width. This gives one "offset" only to the footing, as at *a a'* in fig. 15. If there are to be two "offsets" to, that is two courses in the "footing," the course below that in fig. 17 is shown arranged as regards bond in fig. 18, which with a two-course footing giving two offsets and two courses, as 1, 2, in fig. 16, obviously forms the lower course, fig. 17 being the upper course of the footing as a whole. In fig. 18 the dotted outline *a a a a* gives the position of the second or upper course—namely, that in fig. 17—*a a a a*, fig. 18, corresponding to 1 2 3 4, fig. 17—while the outline *b b b b* in fig. 18 shows the position of the first course of upper wall, corresponding to *a a a a* in fig. 17. The course in fig. 18 is equal to a brick and a half in width, and made up of two outside lines of "stretchers," one at front *c c*, the other at back *d d*, with a row of "headers," *e e*, at right angles between them, two half-brick closers, *f* and *g*, being used at the end. In fig. 19 we give the plan of the course where the footing is of three courses, as 1, 2 and 3 in fig. 16 (*ante*). In fig. 19 the dotted outline represents the course 1 2 3 4 given in fig. 18; here the course is equal to two and a half bricks in width or depth from front to back, and is made up of two rows of "headers," one at front, as *b b b*, one at back, as *c c c*, with a row of "stretchers," as *d d d*, between, and running at right angles to them. *e, e*, are two half-brick "closers," with a quarter-brick closer at *f*.

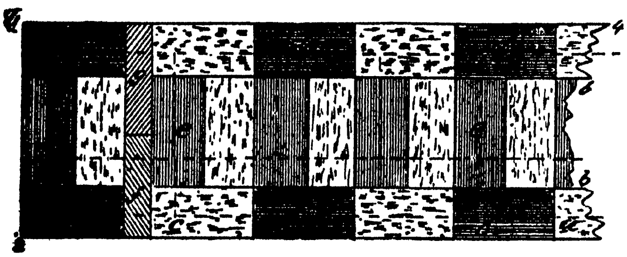


Fig. 18.

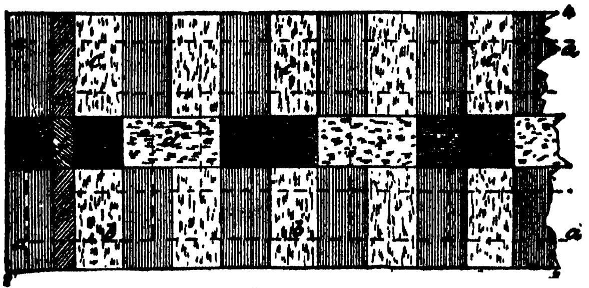


Fig. 19.

In like manner, we may proceed, as in fig. 20, to show a fourth course, where the footing has four offsets and four courses, as at 1 2 3 4, fig. 16. Here again the dotted outline *a a a a* may be supposed to represent the position of the course illustrated in fig. 19, and of which the outline is 1 2 3 4, corresponding to *a a a a*, fig. 20. The course in this figure which forms the lowest or base course of the supposed four-course footing, is made up of three distinct rows, on each of which two "stretchers," as *b b*, alternate with a "header," as *c c*; the front row "stretcher" being *d d*, the back row *f f*, the "headers" being respectively *e e* and *g g*; *h, i* and *j* being half-brick "closers."

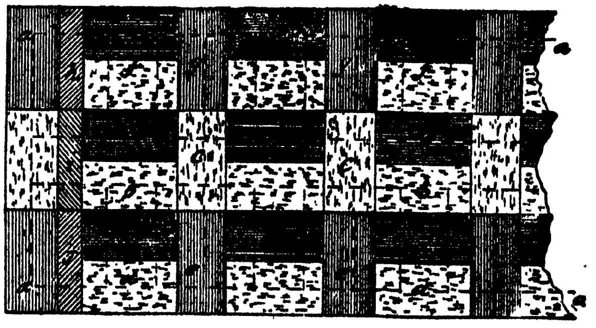


Fig. 20.

Varieties of Walls in Brickwork.

Walls of brickwork may be classed as follows:—*First*, straight-running walls or open walls, finished square or flush at the ends—as, for example, in garden wall *a a*, fig. 21.

THE IRON MAKER:

The Details of his Work and the Principles of its Processes.

CHAPTER VI.

The ores of iron are met with in great abundance in our country, and generally within comparatively easy working reach of the earth's surface, although at times they lie so near it that in some places they actually crop out at it, and are to be had for the mere lifting. It was deposits of this kind which no doubt tempted the curiosity or compelled the attention, so to say, of the early inhabitants of this country, leading them to a knowledge of its characteristics and thereby of some of its uses.

Up to within a very recent period—dating from the firm establishment of the railway system and other means of ready access to different parts of the country—our supply of iron was very limited, so far as kinds or varieties went. Practically, indeed, the iron masters of this country were dependent at one time upon the ores found in connection with our coal deposits. The combination of the coal measures and our ironstone deposits was one of those happy natural circumstances, almost compelling, so to say, prosperity to both trades, of which our highly favoured country can give more than one instance in its social and commercial history. These iron ore deposits were long known as the clay ironstone measures, from being found in the bands or seams of clay permeating the coal fields; otherwise, in a more scientific nomenclature, they are called carbonates of iron. They were, and are, found in great abundance, most frequently in the form of small lumps or nodules; hence the name, "iron*stone*." The ore is, however, found in the form of bands or seams. As we have said, this clay ironstone—or carbonate of iron—was literally the source from which the iron trade derived its sole supplies of ore, during by far the largest period of what may be called the first active era of our iron manufacture. Early in the present century, what is called the "Black-band"—another carbonate of iron—ore was discovered; so called, we presume, from the fact that, although like the clay ironstones found in connection with the coal measures, it contains specifically a large amount of coaly or carbonaceous matter, which gives to the ore a dark appearance, different from the greyish-blue of the clay ironstone. The chief *locales* of these two great classes of iron ore are in Staffordshire, Warwickshire, parts of Yorkshire, South Wales, and in Scotland. The Black-band may almost be called a Scotch ore—its abundance in the western part, near Glasgow, having given the Scottish iron trade its greatest modern development.

The following analyses show the constituents of the two representatives of the carbonates of iron—the last named percentage of the two given after each constituent being the Black-band:—Protoxide of iron, 41·03, 48·66; Alumina, ·23; Clay, 1·21; Protoxide of manganese, ·55, 1·21; Lime, 2·83, 1·69; Magnesia, 3·11, 2·61; Carbonic acid, 28·49, 33·0; Moisture, ·57, ·25; Combined water, 1·36; Phosphoric acid, ·70, ·58; Organic matter, ·07, 11·01; Soluble silica, ·27.

The following are the constituents insoluble in acids in the clay ironstone:—Silica, 13·08; Alumina, 5·56; Peroxide of iron, ·41; Lime, ·17; Magnesia, ·25; Potash, ·86. The percentage of metallic iron in the clay ironstone above analysed was 32·18; of the Black-band 37·80. Of the carbonates of the bulk of the ores passed into the furnace, the yield may be taken at an average of only from 25 to 30 per cent. The yield of richer ores, such as the red hæmatite now so largely used, is much higher—on an average from 50 to 55 per cent.

But although for a long period—up to within, let us say, the last forty years—our iron trade depended for its supply of ores upon the clay ironstones and the Black-band carbonates, the existence of richer ores was not unknown. These latter were only used, as a rule, to a most limited extent; and it was not till rapid, cheap, and easy conveyance by railway was firmly established, that their use became general. The red hæmatites, for example, in one sense the richest of our native iron ores, once scarcely known out of and but comparatively little used in Lancashire and Cumberland, their chief localities, are now used everywhere, and have in their own special districts given rise to an enormous trade, the chief centres of which are large cities and populous districts, such as Barrow-in-Furness. The discovery of the oolitic ore in the Cleveland district of Yorkshire, found in such enormous masses there, has given rise to a marvellously developed trade, and a name to the district which has made the term "Cleveland iron district" household words in all the world where scientific and practical metallurgists are found. The "Cleveland," which is a mixture of a green carbonate with a little silicate of iron, is a poor ore, being largely mixed with debasing constituents such as phosphorus. But it is cheaply got, being partly worked from the surface, partly from below, the bed being of extraordinary thickness, and therefore costs little as compared with the ores of other districts, such as those of the carbonates of Staffordshire or of South Wales. But the iron trade of the present day is distinguished not merely by its using a variety of ores other than those specially got in what might be called their home localities, for foreign ores are now bought in large quantities in this country. The presiding cause of all this activity, the effects of which are felt in the most distant countries where rich iron ores are to be had, is beyond doubt the revolution in the trade caused by the discovery of the Bessemer and kindred processes.

The following are analyses of the leading ores now used in this country, other than the carbonates already named and described. We shall take the ores of the Cleveland district named above as representative of what may be called the most important of our ores after the carbonates; and which certainly have given rise to one of the most active and populous of our iron-making districts.

The Cleveland ores are also, perhaps, worthy of this distinction for another reason—which distinction after all is purely arbitrary and carries with it no point of practical importance save that connected with the classification or order in which we name our own country or what may be called British ores. The reason here alluded to is the fact that it was in connection with the Cleveland ores that the new process known as the Thomas-Gilchrist was first worked practically out; and they are still, in fact, the chief ores with which it operates. We have said that all our ores are more or less mixed with debasing elements, the presence of which tends to deteriorate the value for constructive purposes of their yield of metallic iron. Of those debasing elements the most vicious, so to say, are the phosphorus and sulphur; and of these two the phosphorus is the worst. Now, while all our ores are more or less tainted with these elements, Cleveland ores, abundant as they are, easily worked or "mined," and therefore cheap *per se*, are, as we have said, poor, or in other words unfortunately rich in debasing elements. Their percentage of phosphorus and sulphur is so high that they have been practically excluded from all the advantages of the new processes of steel making, such as the "Bessemer" or "Siemens" or "Siemens-Martin."

Hence the vast importance to the Cleveland iron masters of any system of working by which the ores could be so treated as to render their phosphorus and sulphur so innocuous as to get rid of them, so that the new steel processes could be applied to them. It is obvious that, being in the first instance abundant and cheap, any such system would add enormously to their value, giving a product which, in place of being if not the very lowest in price of any "pig-iron" in the market, certainly amongst the lowest, is at once raised enormously in value. Hence, not merely with special reference to the Cleveland, but having in view the importance of raising the value of all other ores in which debasing elements are more or less but always present, the eagerness with which practical and scientific metallurgists have been for a long time endeavouring to find out a method of so treating ores as to get rid of the evil effects of the debasing elements. It was reserved for two men, both of whom were in years young—one, alas! Mr. Thomas, was taken from our midst in the very prime of life—and neither the one nor the other in any way primarily connected with the iron trade, to have discovered a method of so treating ores that from such as those of the Cleveland district a new or mild steel like that of the Bessemer process should result. It is not here claimed for Messrs. Thomas and Gilchrist that they alone have solved the problem which has engaged the attention of so many men for so long,—other claimants for other systems have, and others may yet, come forward,—all that we claim to have the right to say is, that the method discovered by those gentlemen is the first which has proved itself commercially successful. In making it thus they had the good fortune to become associated with Mr. Richards, the engineer of one of the largest iron making establishments in the world—that of Messrs. Bolckow and Vaughan, near Middlesbrough in the Cleveland district.

Trusting to the ability no less than to the prudence of this engineer, this wealthy company paid special attention to the working of the Thomas-Gilchrist process, and so that they in a short time proved that it was well worthy of forming a part of their regular working. Visitors to those celebrated works can now see the pig-iron of the Cleveland ores, taken direct from the blast furnace to the "Bessemer converter," changed into a mild steel of a vastly greater money value per ton; and if they have time and patience at their disposal—and not much of either will be called for, so short is the actual time—they will see this steel rolled into long rails, some hundred and fifty feet long, then cut into the shorter lengths, thereafter drilled with holes for the bolts of the "fishing joints," and passed aside ready to be shipped and used. There are vast capabilities in this new process, of which the reader may rest assured that, if space permits, we shall place before him full details; and it is this importance which justifies our dwelling upon the Cleveland ores, which have been the means of giving it the first place in the high position it now takes amongst the practical working systems of iron and steel making.

We are now prepared to give the analysis of a Cleveland iron ore. The ores of this district are generally classed as the Oolitic ores, being found in the geological formation bearing that name. The ores of the counties of Northampton and Wilts belong also to this class; as do also those found in Lincolnshire to some extent, and to a much less extent in Oxfordshire. Following the order of the analyses of the carbonates already given, we take the constituents as thus: Protoxide of iron, 39·92; Alumina, 7·86; Protoxide of manganese, ·95; Lime, 7·44; Magnesia, 3·82; Carbonic acid, 22·85; Combined water, 2·97; Phosphoric acid, 1·86; Organic matter, ·03; Silica soluble, 7·12.

THE STEEL MAKER.

The Details of his Work—The Principles of its Processes—The Qualities and Characteristics of its Products.

CHAPTER VIII.

At the end of last chapter we stated that the fracture of blistered steel bars was easy compared with that of a bar of puddled or wrought iron—that it was divided more by breaking than by rupture, just as we have to tear asunder or separate by stretching out the fibres of a cord of flax, wool, or cotton, when we can break across a stick of hard sealing-wax by simply snapping it asunder. When we examine the bar of wrought iron ruptured or torn asunder, we see at once the fibrous character of the mass; when we break a bar of blistered steel we see its granulated constitution, crystalline, and of a bright metallic, almost white lustre. The grains or crystals are large in proportion to the degree to which the carbonisation has been carried out. But the change in the character of the metal does not rest with the change in the constituent molecules: there is as complete a change in what may be called its special characteristics. It is capable of being hammered, rolled, or drawn out like the original wrought iron; but it is further capable of being hardened and tempered after being wrought into any desired form, and brought to a fine cutting edge, permanent under proper usage.

The Cementation Process of making Steel.—Its Theory.

The way in which these singular charges are effected by the operation of the cementation process is not absolutely known. The most probable theory is this; and it is based upon, and the phenomena to a large extent proved by, the experiments of Dr. Graham, who showed that metals, and amongst them iron, are capable of being permeated by certain gases, the operation being facilitated by the application of heat. The original or wrought iron in its decarbonised condition placed in the cementation chest is surrounded by or may be said to be placed in a bath of charcoal. This charcoal is a source from which a large supply of carbon may be drawn; and this the charcoal readily enough gives out or up. The outer skin or fibre of the bar absorbs or takes up this, or is, as Dr. Graham's experiments show, permeated by the carbon, which forces itself, as it were, into the molecules of the iron. This is supposed to extend only to a certain, and this a small depth. But while the molecules of the iron readily take up or absorb this carbon, they as readily give it out. The result of this is supposed to be that the carbon taken up by the first or outer film of the bar is taken out or given up by the film next in sequence to the first carbonised film. But the first film, thus —for a time only—deprived of its carbon, takes up immediately from the charcoal surrounding it a second dose of carbon. This goes on till at last the central core or part of the bar is reached. We conceive of this process as in fact one in which a certain amount of carbon has a tendency to travel to or be drawn forward to the central part or core of the bar; the progress being made by a series of progressive movements made at intervals. A popular notion of the process may be conceived by supposing the bar to be a mass of dry porous material, which is capable of absorbing moisture, or which can be penetrated by a stream of vapour-moisture which we can easily conceive to be projected or forced in the direction of the central core of the bar. As one zone receives its portion of moisture, it gives it up to the next zone nearer to the centre; the first zone receiving another volume of moisture from its original source, taking the place of that which it gave up to the second zone. This goes on with each successive zone till the central core is reached, which finally takes up the moisture from the last of the zones surrounding it. We have thus a series of zones alternately receiving and giving up, till an equilibrium is restored, and the whole mass becomes moist. Such is probably the most scientifically correct theory accounting for the change which takes place in the character of the metal submitted to the cementation process; there is, of course, much of conjecture in it, although based upon apparently sound deductions from experiment.

But whether or no the carbon is conveyed to the different parts of the steel bar in the way here explained, the fact that it is conveyed in one way or other is none the less striking and suggestive. Suggestive, however, of difficulties; for although it is carried in some way or another, the precise nature of which we do not absolutely know, the fact does not not account for the singular change in the metal which gives it characteristics so altogether and so singularly different from those which it possessed before cementation. In view of all the difficulties in the way of saying or deciding positively how the change is brought about, not a few of our able scientific men prefer to refrain from propounding or accepting theories, and to say frankly that all we know is that we know nothing definitely,—all that is left us being conjecture, and that mere conjecture is not scientific, which deals only with facts which we know, though it may lead to something which may lay claim to be essentially scientific.

But if the reader will consider the conditions in which the process of cementation is carried out, as we have described it, he will perceive that even if this system of permeation by an absorption of the carbon is carried out as above stated, there ought to be—and we know in practice that there is—a great inequality in the way in which the carbon is taken up. The carbon in the charcoal is a fixed quantity, and it is not possible to conceive that it can give out more than it possesses; the zone of any bar nearest the surface, or, as we may call it, No. 1, will receive a larger amount of the carbon than the zone farthest from the outside, and which we may designate as No. 7; No. 3, or the middle zone, receiving a portion between that received by the first and second. The theory we have already explained may meet this difficulty; but it will do so by assuming that each zone gives out to its next neighbour, or, so to say, passes on to it, the whole amount of the carbon it receives. This may be, but it is not likely in view of actual facts. But even granting that it can give up all it gets, this does not meet the difficulty arising from the fact that the different zones will have different absorptive powers, one zone taking up more carbon than another. Nay, each zone may have different parts of it having different absorbent powers, so that there may be different values of steel at different parts of its length. We know that this difference of absorptive powers must exist in the bars; for at least it would be a dangerous thing to say that any one bar was perfectly homogeneous or of uniform quality throughout. Differing itself in constitution, it will give different absorptive powers at the differing parts.

Shear Steel.

But a metal to be useful in all the circumstances of its use must be of uniform quality, so that it will be a matter of indifference what part of it be taken for working, as all will be alike. But this uniformity is rarely arrived at in steel obtained from the cementation process, and this, so far as we can conjecture, for the reasons we have stated. Hence the object of the steel maker is to secure a metal as uniform in quality throughout as he can obtain. This he does upon the same principle on which the wool spinner obtains a blend or quality in the mixture desired by taking fibres of different value and characteristics and mixing them thoroughly by means of appropriate mechanism and appliances. The steel maker therefore takes bars of steel produced in the cementation process, and all of which he pretty generally concludes not only differ in precise value from other bars, but that each bar is in itself of unequal quality, one part of its length differing from another part of its length. The cut portions if huddled together would represent a mass of very varying materials: one part might lie next to another part, each part having in excess some constituent or quality which the other lacked; a mixture of those two would obviously give, if it were thorough and complete, a quality pretty nearly approaching that which might be desired. This mixture, so to call it, of the parts of different bars is made by the steel maker, by taking a number, tying or packing them together in bundles called technically "faggots," and placing them under the action of a high temperature till a white or "welding heat" is obtained. Each faggot is taken out of the furnace and hammered out by a powerful hammer, giving such a high number of blows per minute—300 to 400—that the temperature is maintained by the mere heat evolved by the percussion. This gives a product known as "shear steel,"—not from the fact, as some supppose, that it is used for shears or large scissors making, but from the fact that it is made from bars cut, shorn, or divided. And the value of the "shear steel" is indicated by the number of times the bars are cut or shorn, faggoted, welded and hammered out. In all cases after the hammering is completed the mass is taken out and rolled into bars. The bars of the first process are then cut, faggoted, welded and hammered, and finally rolled into bars. According to the number of times this process is repeated is the product named—the qualities being known in the trade as "shear steel," "single shear steel," "double shear steel."

But although by this process now described a metal is obtained pretty uniform in quality, it is far from possessing that homogeneity which steel of the highest quality, used for cutting instruments of the finest kind, should have: this quality, which combines the two qualities of extreme toughness and hardness, is and can only be obtained by a mixture infinitely more complete than can possibly be had from a process which is so largely mechanical as that of cutting and faggoting last described. The process of mixture thus explained can only be got by a fluid mixture—that is, by melting the different lengths of the cut bars of the cementation process. This melting is carried out in crucibles; hence the term "crucible steel" as indicating that of the finest steel produced.

Crucible Steel.

The crucibles used in the making of this steel of the highest quality are made of a very refractory material: a mixture of fire-clay—which material forms its principal bulk—with ashes and potsherds reduced to powder. The crucibles are of various sizes, capable of holding from thirty-five to eighty pounds. Ordinary dimensions are sixteen to eighteen inches in height, some five to seven in diameter at the mouth and bottom; the sides bellying out with something like a parabolic curve, giving a diameter at the widest part, at a point about one-third of the whole height from the bottom, a little in excess of the diameter at bottom. Refractory as are the materials of which they are made, from the high temperatures to which they are exposed as well as from the somewhat rough treatment—on account of the weight—in handling, there is a very large percentage of loss through breakage. This, with the great consumption of fuel necessary to keep up the high heat required, makes the process of crucible steel making a very costly one.

THE YOUNG ARCHITECT OR ENGINEER.

HIS STUDIES—OFFICE DUTIES—AND PRACTICAL WORK IN THE PREPARATION OF WORKING DRAWINGS, OF SPECIFICATIONS, AND CONTRACTS FOR WORK.

CHAPTER X.

AT the conclusion of last chapter we pointed out the necessity there is that the young architect should possess a thorough knowledge of timber used in construction. If ignorant of its qualities and characteristics he might design woodwork which is to be exposed to the weather of timber only suited for indoor work, and specify sizes which may entail great waste and unnecessary cost.

The mode of preparing these drawings varies very considerably: some architects ink-in and colour every detail; others ink-in those drawn to scale, and leave the full-size details in pencil; whilst many leave all the details in pencil, and merely colour what is absolutely necessary to make the drawing intelligible. The second system is the one recommended. The young architect is advised not to begrudge the time required for carefully completing the half-inch or inch scale details, which should all be in the first instance worked out in pencil, then inked-in, carefully coloured, and finally "written to"—that is, lettered and figured where required.

Details are generally required by the bricklayer, mason, carver, carpenter, joiner, ironfounder, smith, plumber, glazier and plasterer; also for tiling, parquetry, heating and ventilating. It is much easier to state what does not require a detail drawing than what does; generally every portion of a building that is not a perfectly plain surface requires one.

A few hints on each trade will complete this portion of the subject.

Details of Drawings required by the Bricklayer and Mason.

The bricklayer and mason will be the first to ask for details. Let the reader imagine the front elevation of a small villa to be erected of brick and stone, with a porch, bay windows on either side, balconettes to the first-floor windows, brick and stone string-courses, elaborately moulded window sills, heads, arches and jambs, gables and dormers. Separate inch-scale details will be required of the porch, with its small shafts, bases, caps, enriched arches, keystones, gablets, finials, etc., of each bay window if they differ in design, of the first-floor windows, of the gables, dormers and chimney-shafts. Each of these drawings must consist of at least one plan and two elevations and sections. Full-size details must be drawn of the plinth, window sills, heads, moulded arches, keystones, jambs, balconettes, and the brackets carrying them, of all string-courses, labels, parapets, of all stone and ornamental brickwork in the gables and dormers, including foot and apex stones, of the chimney bases and caps, as well as of every portion of the porch. In the interior of the house elevations of the principal chimney-breasts may be required, showing the arrangement of the flues by dotted lines. The chimney-pieces in the principal rooms should be erected from the architect's own design; he must also prepare full-size drawings of all carving, ornament, and incised work. Let the young designer place himself in imagination in front of any large building, and note every stone on which there is any work in addition to plain face work, and all brickwork in any way varying from plain walling; he will then have no difficulty in forming an idea of the number of full-sized details required by these trades that have been prepared at the time the building was being erected. The architect should leave nothing requiring thought to the bricklayer and mason, for that it is a rule with workmen not to think about their work all who have had much to do with them know but too well. Yet, while stating this, let us be just in the matter, if not generous; for it is obvious that in one direction, if workmen did think for themselves, the result of that thinking might be that they, seeing that they could really improve the work in hand, might in so doing alter it, and in this alteration offend the architect. We have heard those who at other times have complained of men not thinking, complain with greater bitterness of the thinking, telling the men they had no business to think, but to do their work only. The true position is, that, assuming the drawings to be correct, the workman should think as to the best way of giving the best work in order to do full justice to the design: it is for lack of thought in this direction that censure of workmen is more frequently demanded than it ought to be. We are far removed, in but too many instances, from the old times when workmen took a true pride in doing their work as well as it could be done, loving it for its own sake and not only for the money it might bring them.

Details of Drawings required by the Carpenter and Joiner.

Continuing the reference to a small villa, half-inch or inch scale details will be required by the carpenter and joiner, (1) of the frames, sashes or casements, sills, mullions, architraves, shutters, linings and bottom of each window varying in design from the others; (2) of the front, back, and other doors, including the frames, casements, architraves, blocks and fanlights; (3) of the vestibule and all other framing; (4) of all the skirtings, base and plinth moulds, dados and wall panelling; (5) of the wood ceilings and cornices, if any; (6) of the staircase, showing both its construction and design, the newels, balusters, handrail and framing; (7) of all skylights and ceiling lights; (8) of all the fixtures included in the joiner's work. The sections of all moulded woodwork, carving and ornament, must be drawn full-size; thus, sections should be made of the window sills, meeting rails, heads, frames, mullions, of all framing and architraves.

Detail Drawings required by the Ironfounder and Smith, Plumber, Glazier, and Plasterer.

The ironfounder and smith will require inch-scale and full-size details of all cast- and wrought-iron work; for a small villa, drawings will probably only be required for finials, roof cresting, rails to balconettes, and grilles in fanlight. In larger buildings, details must be made of columns, base-plates, cast- and wrought-iron beams, and of all other ironwork of every description.

The plumber and glazier will require details of all ornamental leadwork and glazing, and all special work connected with the water and gas supply. Full-sized sections of all plaster cornices, centre flowers, brackets, beams, pilasters, caps and bases, cement dados, mouldings, angles, stops, architraves, archivolts and plinths, must be made; for the plasterer, inch-scale plans of panelled ceilings, and elevations of all ornamental internal plaster work.

From this general summary the young architect will be able to form a tolerably clear idea of the number, variety, and importance of these drawings; it will be evident that in a building of any size and elaboration of design a large number will be required, and must be provided from time to time from the commencement to the completion of the building.

Duplicate Drawings.

We have now described the preliminary sketches, contract drawings, duplicates for the local authorities, and details; but this formidable list does not include the whole of the drawings the architect has to prepare. Duplicates or tracings have to be made of the contract drawings and details for the use of the clerk of the works or contractor. They are either prepared on tracing paper and mounted on paper or calico, or on tracing cloth. Great care must be taken that nothing is omitted from the tracings, which should therefore be carefully compared with the originals before they are sent out of the office. Every drawing after it has been traced should have the word "traced" placed in the left-hand lower corner; a record should be kept of all tracings given to the clerk of the works or contractor, and a suitable box provided on the building for the reception of these tracings.

Specifications.

A specification is an accurately written description of all the materials, labour, and the mode of construction of a building; it is explanatory of the contract drawings, and, taken in conjunction with them, should make every portion of the building, from the footings to the chimney-caps, intelligible to the client, the contractor, and his foremen. Gwilt states: "The importance of an accurate specification or description of the materials and work to be used and performed in the execution of a building is almost as great as the preparation of the designs for it." The experience of the young architect will be severely tested by the preparation of this important document; it is generally prepared immediately after the completion of the contract drawings: it commences with a series of general clauses, then describes the materials and labour that must be provided by each trade, and concludes with a number of conditions binding the contractor to carry out the works in a certain specified manner; or the "conditions" may preface the detailed description of the work to be done, following upon the title and the general clauses.

The specification is generally written on large sheets of foolscap paper, and only on one side of each sheet; when preparing it, the architect should have the whole of the contract drawings spread out on a large desk, so as to be able to refer readily to each one. General clauses should be avoided. The architect cannot enter too much into detail, and as omissions generally result in "extras," great care should be taken to make the specification complete. Several of the points concerned with the important departments of specifications, and the legal responsibilities which as documents they carry with them, may, if space permits, be fully discussed in a succeeding chapter. In buildings involving a considerable expenditure in erection, and in finishing the interior in a style fitted for the position and to meet the requirements of the owner or occupier, it is usual, and it is certainly a safe and prudent plan, to accompany the specification or precede it with a document purporting to be that which defines the relation which the contractor bears to the architect, and through him to his client or employer, for whom and at whose cost the building is to be erected. This relationship is embodied in what are called "the conditions of contract," or simply "the conditions." The following may be taken as a specimen or example of what those conditions are in the case, say, of a house, the "plans" of which are illustrated in figs. 1 to 10.

The General Conditions attached to Specifications.

"General conditions upon which the contract for the erection of a (villa or mansion, etc.) is to be carried out, or upon which it is based, as in the drawings numbered Nos. 1 to — inclusive, together with the accompanying specification,—the whole, with detail drawings in sheets numbered 1 to —, being prepared by Messrs. Blank and Co., architects.

"In all cases of reference and dispute the drawings and specifications are not to be taken as separate, but together as constituting one document, and each one connected with the other.

THE ROAD MAKER.

HIS WORK IN THE LAYING OUT OF ROADS IN RURAL SUBURBAN AND TOWN DISTRICTS, THEIR CONSTRUCTION, REPAIR, AND IN THE CHOICE AND USE OF THE VARIOUS MATERIALS EMPLOYED.

CHAPTER VIII.

AT conclusion of preceding chapter we alluded to the subject of "retaining walls" as used in deep road cuttings. We here give merely a suggestive illustration of this class of wall, to the right of the sketch in fig. 12, *d d* being the rising ground at back, *e e* the wall, provided at frequent intervals with small open ducts or channels, *f, f,* to allow the water percolating from the soil of the bank behind to pass through, and thus prevent its forcing-out action on the wall, which otherwise it would exert, either to the injury or destruction of the wall or part of it.

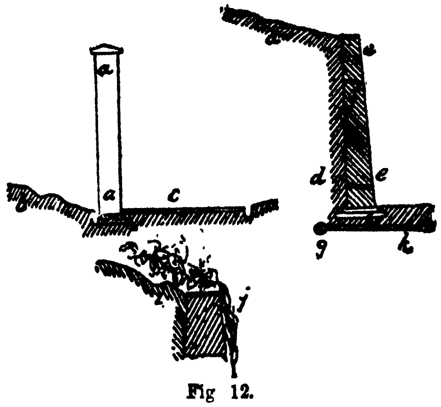


Fig 12.

A still more complete precaution against the lodging of water behind the wall, *e e*, will be a drain, *g*, running along the whole length of foot of wall, and connected with and draining into lateral drains, *h*, which should be laid to and connected with the main drain of the road. The sketch at bottom of fig. 12 shows roughly how by twining ivy along the upper or coping edge, *i j*, of the wall, *e e*, and down the front of the wall, a very pleasing effect may be obtained. Contrary to a popular opinion very largely held, the ivy will tend to keep together the parts of the wall to which it acts as a covering, and protect its surface from rain and damp. The sketch to the left shows an ordinary wall, *a a*, erected at the edge of the footpath, *c*; the ground, as at *d*, rising only to a very slight elevation above this. The allusion to drains just made brings us now to consider the

General Subject of Road Drains.

On this department of road work we have already made an incidental remark or two in connection with fences, the two being in a measure one, or at least there is a close connection between the two. The road may be drained either by open ditches at the side or by specially constructed drains. When ditches are used—which, as being the easiest of construction, they may in new countries, colonies, etc., and in remote districts—these ditches should, for the safety of passengers, be on the field side of the fences, from the roots of which should be an escarpment of at least eighteen inches. The ditches in question may be three feet wide at the top, one foot wide at the bottom, and three feet in perpendicular depth. Should the soil in which the road is constructed in any degree require to be drained, there should be a drain 2 ft. 6 in. deep below the channels of the foot and horse paths, and laid with 3-inch pipes to receive the water collected by 1½-inch pipes in drains across the road, either direct or in the form of irregular or zigzag lines at from 15 to 30 feet apart, according to the degree of wetness of the soil. The said side drains should have outfall drains laid at proper places across the paths, to discharge into the open ditches. Should the soil in which the road is constructed not require to be drained to render it perfectly dry, then drains need only be laid from the side channels across and below the paths at proper places in the course of the road to convey surface water from the road to the ditches on the field side of the fences. The last-mentioned drains across the paths may be from 18 in. to 2 ft. in depth, and laid with 3-inch pipes.

In a Parliamentary report on the drainage of sites of towns, on road drainage and that of suburban lands, issued some years ago, there was much practical evidence given on the subject of road drainage, which it would have been well for many of our townships had it been known and acted upon by those who have had the charge of the roads. We have drawn pointed attention in preceding and recent paragraphs to the evils attendant upon the open ditch, all the more decided in their operation when the ditches were placed in relation to the road or its footpath in obvious violation of common-sense principles, to say nothing of those of road engineering. We have referred to the advantages of altogether getting rid of them, to some of which we shall have occasion presently again to refer. But we would here point to some methods of rendering those ditches less useless and offensive than they often are. And the report we have just referred to contains some very suggestive remarks on them.

In carrying out plans of field drainage, roadside ditches are often found to form most serious obstructions to their work. Covered tubular drains, as presently to be illustrated, would of themselves effect considerable land drainage: in some suburban lands, much intersected by paths, etc., so much so that further drainage might not be desiderated. Many agricultural authorities are in favour of the substitution proposed. Mr. Josiah Parkes states that the drainage of the roads by covered tubular drains would much benefit the adjacent land. In a very stiff clay soil the road drain thus constructed might not act upon the land for more than twelve or eighteen feet; but in free soils, authorities are of opinion that a single drain would affect land beneficially as a drain for one or two chains. Mr. Parkes mentions one such drain, from five to seven feet deep, draining a field of twenty acres. But not alone as excellent outfalls for the drains of adjacent lands would roadside tubal drains be available. Eminent land surveyors believe that it would be of great advantage to farmers if they could be allowed to carry drains into roadside tubular drains. The great objections to open ditches lie in the following considerations. It appears, for example, to be an established fact, that a proper covered drain, of the same depth as an open ditch, will drain a greater breadth of land than the ditch can drain. The sides of the ditch, moreover, become dry and plastered, and covered with vegetation. The absorptive power of the ditch is inferior to that of the drain, even though the former is not covered with vegetation. It is calculated that a mile of double road drains would drain from fifteen to twenty acres of land. Another point of view of this subject, and to which we have made pointed reference, is the loss of land taken up by the open ditches, and which, if covered up, would be easily available for agricultural purposes. It is calculated that on a mile of road with ditches on both sides there is from three-quarters to an acre of evaporating surface of stagnant moisture formed by the ditches. If those were made up, an equivalent amount of dry or cultivable land could be obtained. The Wall Reeve of Poplar Marsh informed the commissioners appointed to inquire into the sanitary condition of the Metropolis that the area of open ditches or sewers within the open parts of his district of 520 acres is twenty-one acres, or in the proportion of one acre of water to twenty-five of land, and he states that the whole of this might be available for grazing and other purposes.

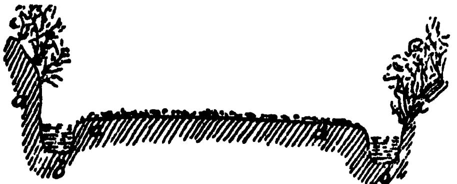


Fig 13.

The Drainage of Roads (*continued*).

The water thus lying in the roadside drains is necessarily, in the words of Mr. Stewart, an eminent land surveyor, "stagnant surface water, and nothing more." So that in a sanitary point of view, the doing away with what may thus be called ranges of "open cesspools" is of great importance to the inhabitants of the surrounding districts. Again, the roads thus drained would be more easily kept in repair. "At the height," says Mr. Stewart, "at which the water stands in these ditches—very often within a foot of the surface of the adjoining land, sometimes higher—it keeps the road soft, and the land adjoining much wetter than it ought to be—often a quag." In fig. 13 we give a diagram showing a road, *a a*, drained with open ditches, *b*, *b*; *c d* being the high bank on both sides; in fig. 14 a road is shown drained with the tubular drain, as at *b* and *c*; the ditch in this case being filled in with stones, as at *f*. The road water may either be discharged through a layer of broken stones or permeable gravel, as at *f*, to stop the silt or road detritus from passing into the drain; or, what will be preferable, it may be taken from the surface by grids placed at intervals along the road leading to "traps," or gulley-shoots, *d*, the detritus being deposited in this, and removed from time to time; the clearer water running down the drain to the main drain in the manner hereafter shown.

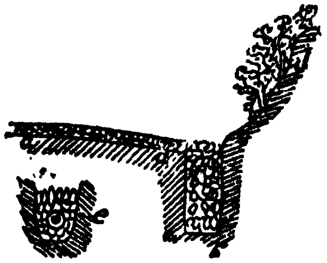


Fig 14.

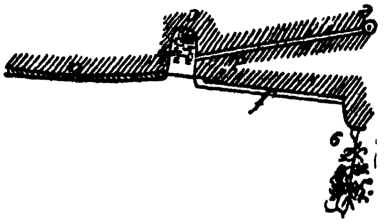


Fig. 15.

Drainage of Roadside or Foot Path.

It will be observed in the two last illustrations that the wall surface is bounded on either side by the drains lying immediately in connection with the edges or outer lines. But in many cases—indeed, in all well planned roads—at least one foot or side path is provided. This requires also to be drained, and if placed outside the drain corresponding to the drain *b*, fig. 14, in position, the footpath may drain into it as in fig. 15, at *b*, this serving both for the road *a* and the footpath *c*. Where, however, there is a ditch outside the footpath, as in fig. 16, the arrangement shown will be the best. In this *a* is part or outside ve[illegible]e of the main road, *b* the side drain, which receives also the surface drainage of part of the footpath *d d*, part shedding into the ditch *f*.

THE DOMESTIC HOUSE PLANNER.

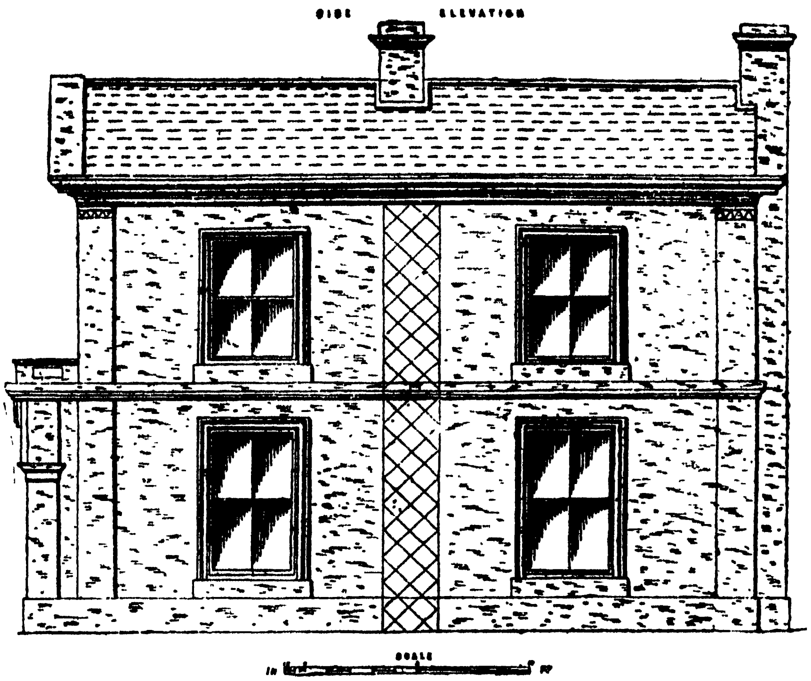


FIG. 1.

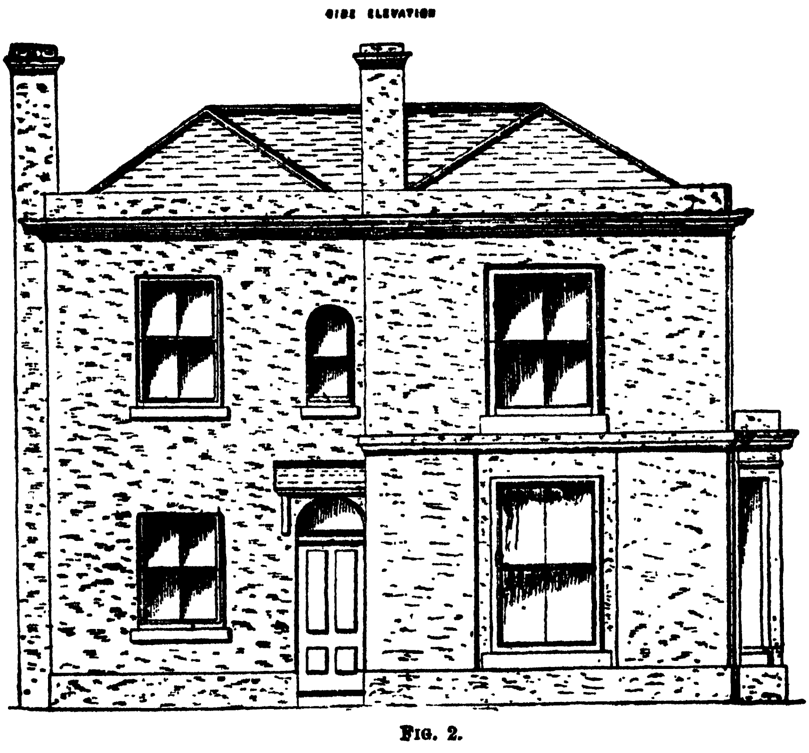


FIG. 2.

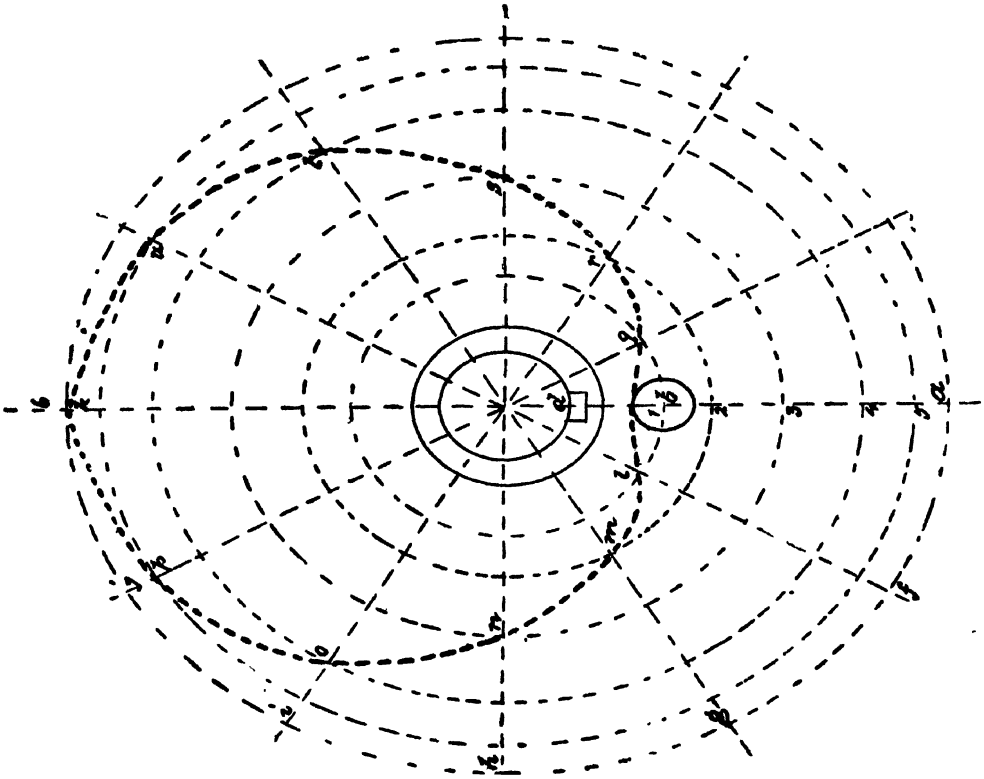
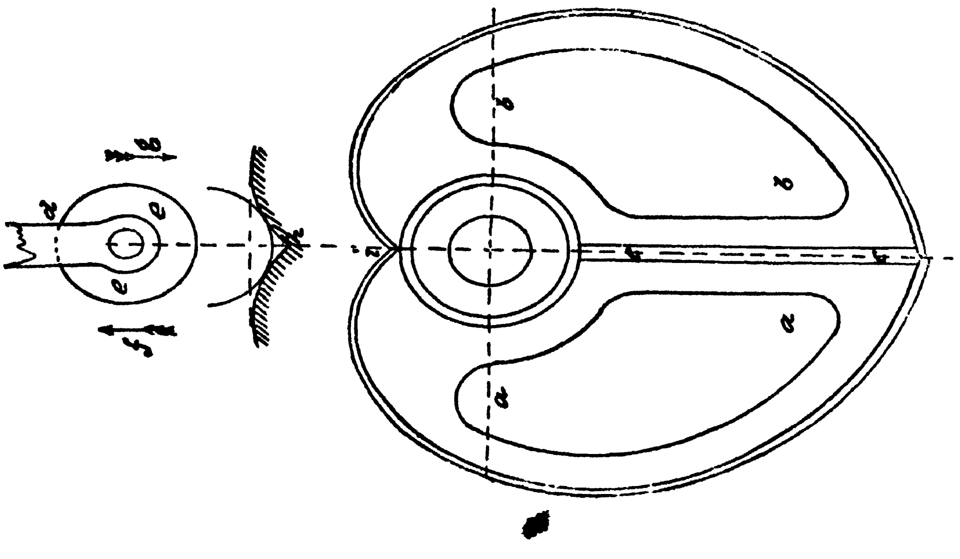


Fig. 2



GOTHIC WINDOWS.—FIGS. 1 AND 5, PERPENDICULAR. FIGS. 2 AND 4, CURVILINEAR AND GEOMETRICAL DECORATED. FIG. 3. EARLY ENGLISH (LANCET ARCH). FIG. 6. EARLY ENGLISH (EQUILATERAL ARCH, INTERIOR). FIG. 7. DO., EXTERIOR.

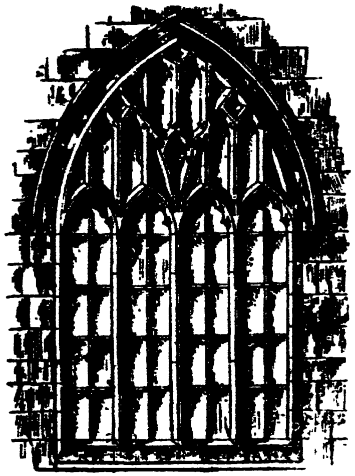
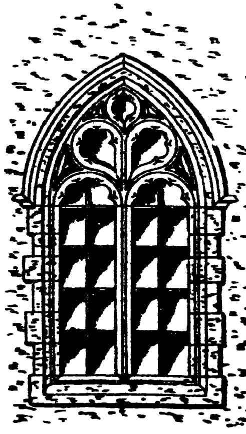


FIG. 1.



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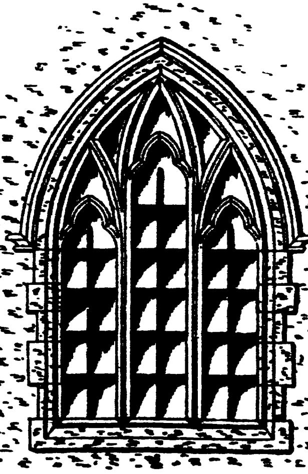

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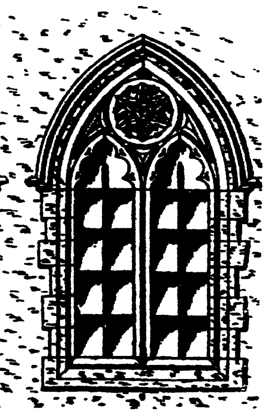


FIG. 4.

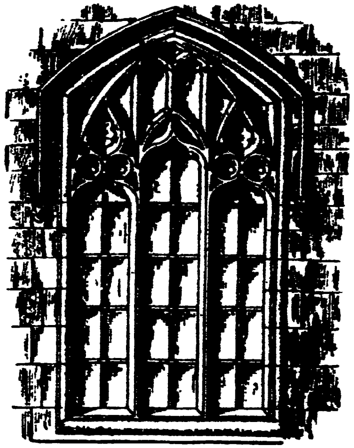


FIG. 5.

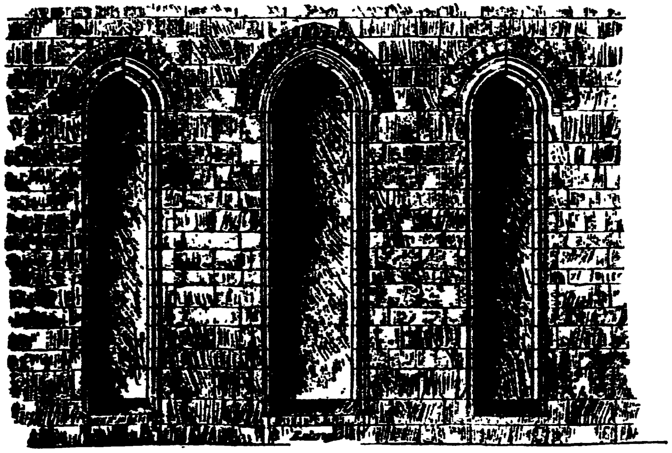


FIG. 6.

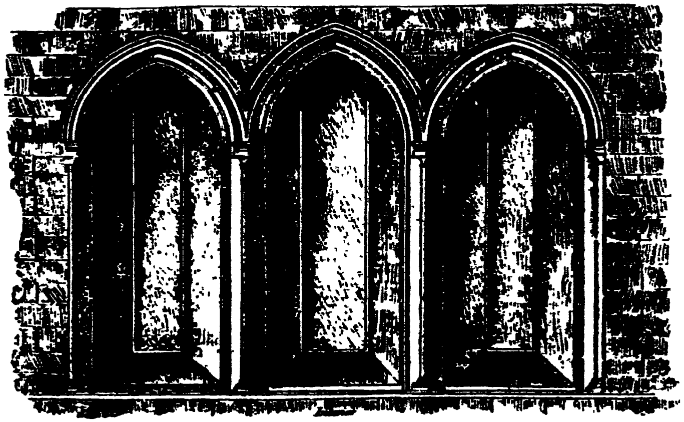


FIG. 7.

THE JOINER, (see Text).

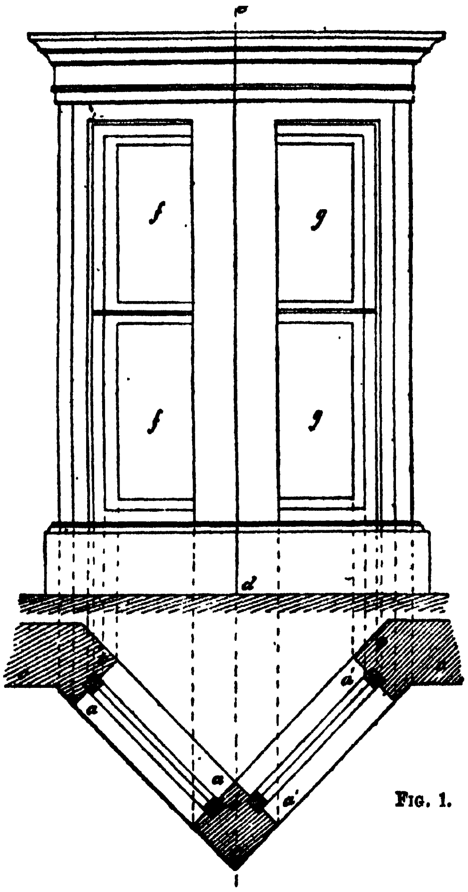
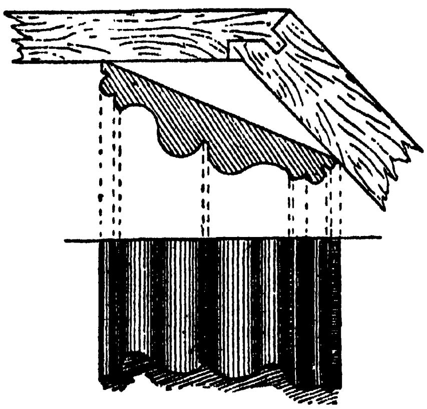


FIG. 1.



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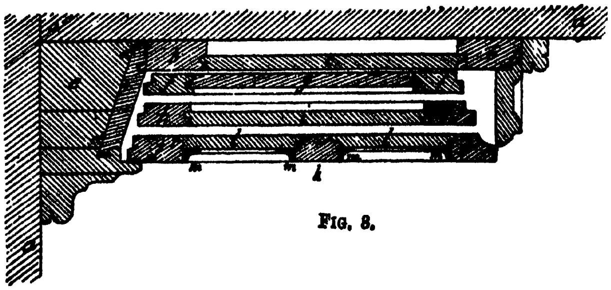


FIG. 3.

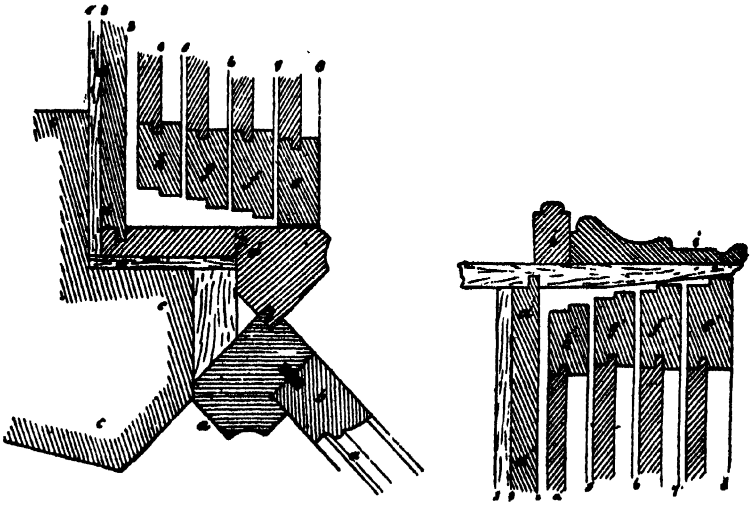


FIG. 4.

Figs. 1, 2, 3. Elevation, End, and Details of Conservatory in Plate CXCII.

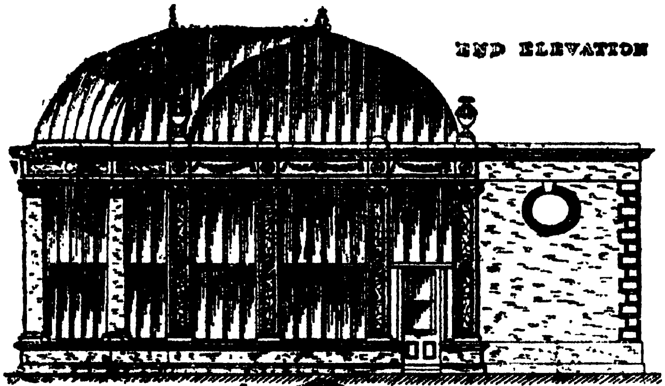


Fig. 1.

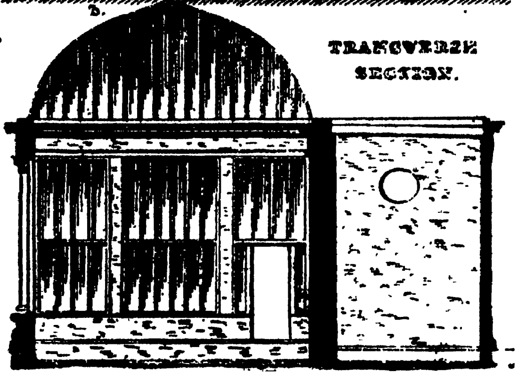


Fig. 2.

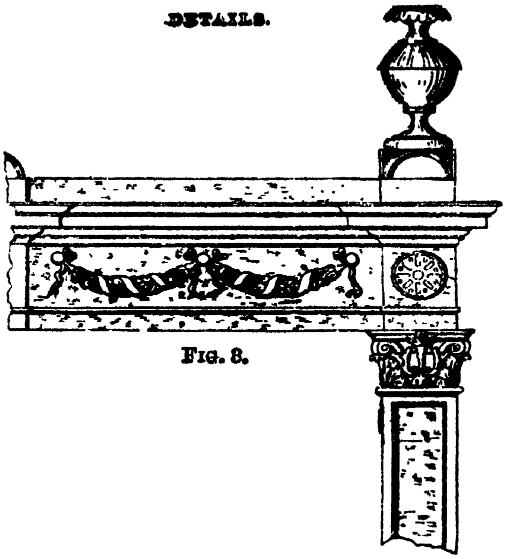


Fig. 3.

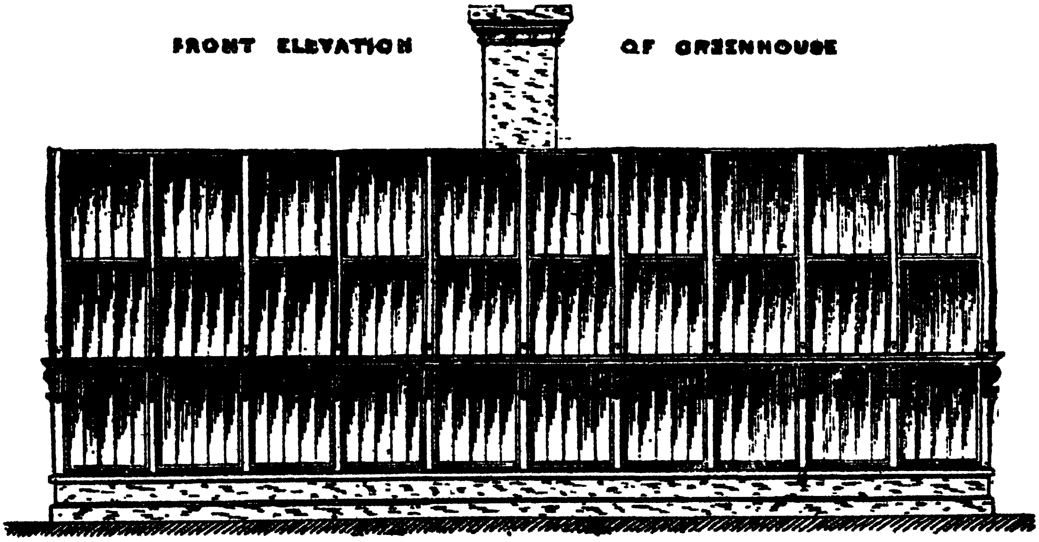


Fig. 4.

GROUND PLAN.

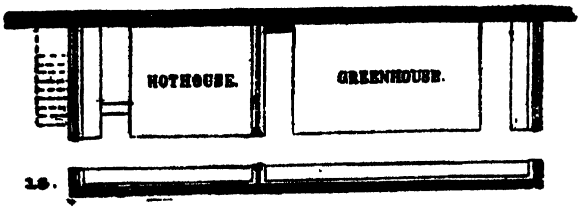
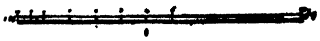


Fig. 5.

Scale for Elevation.



Scale for Ground Plan.

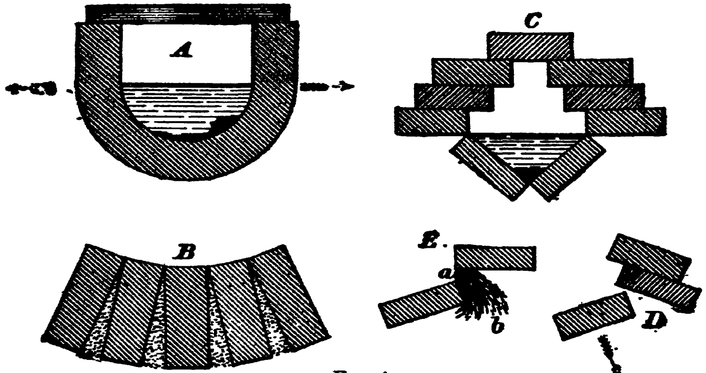


FIG. 1.

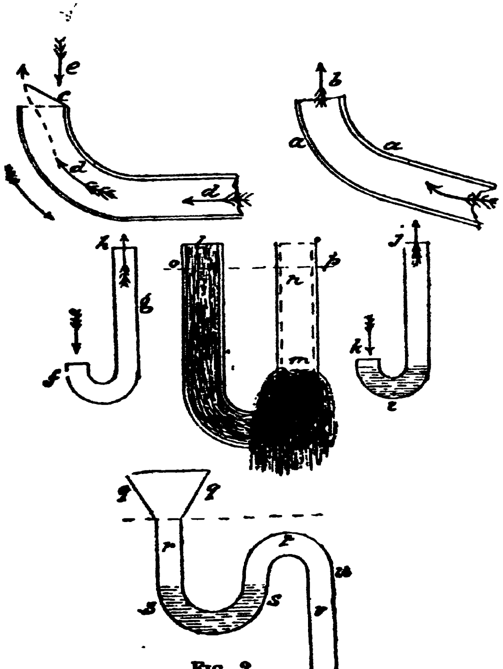
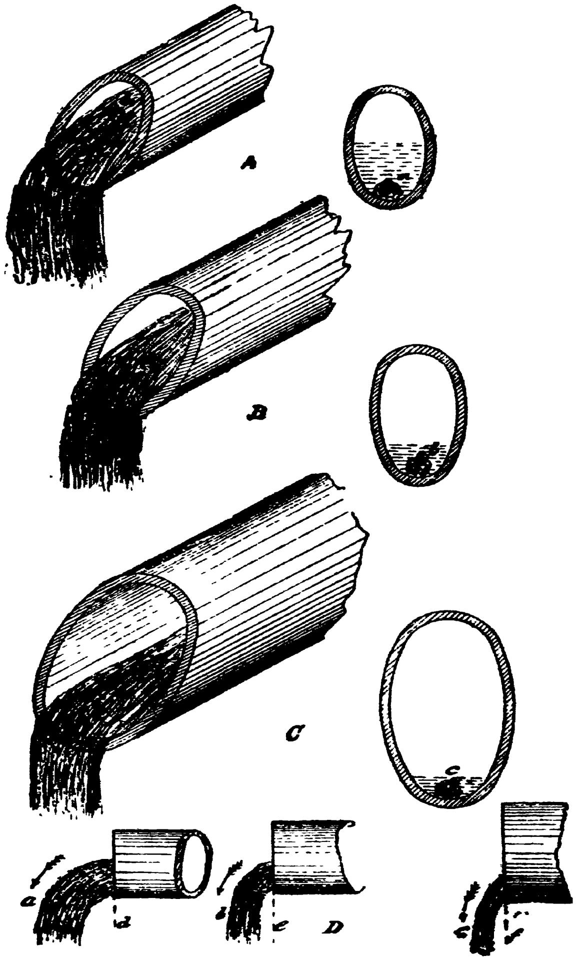


FIG. 2.



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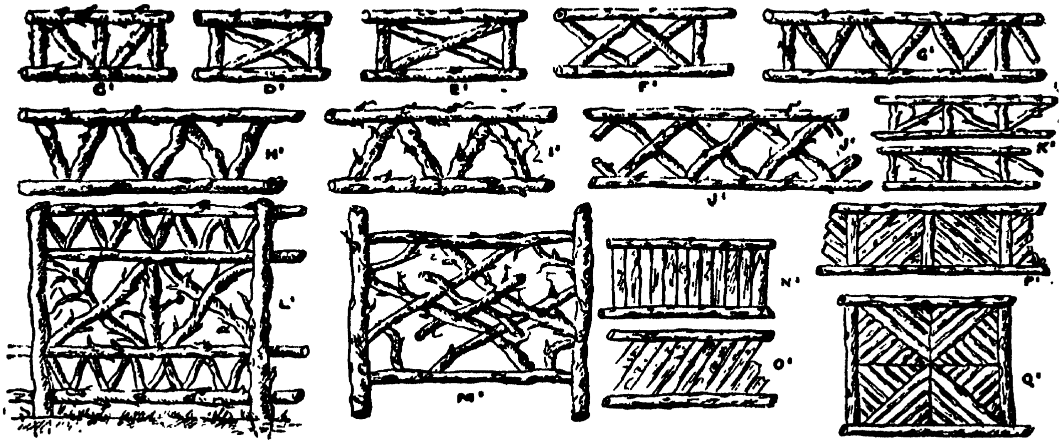
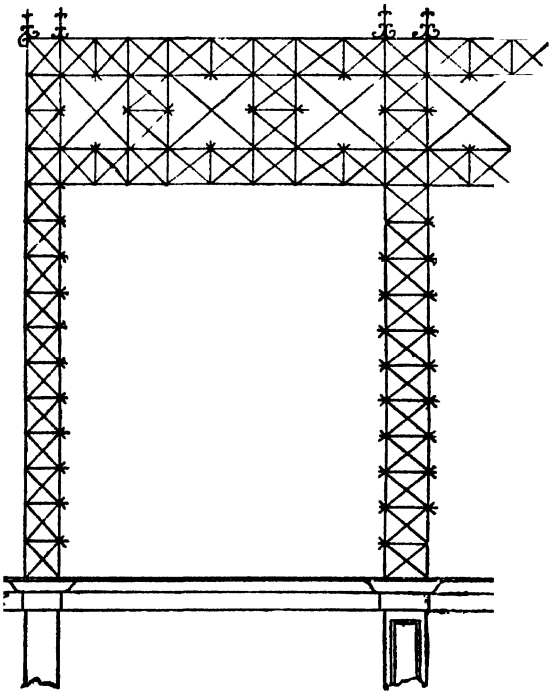


FIG. 1.



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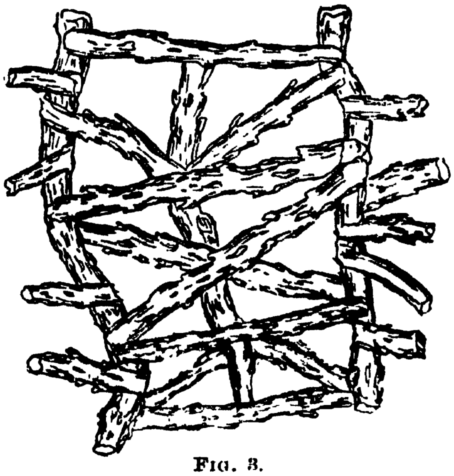

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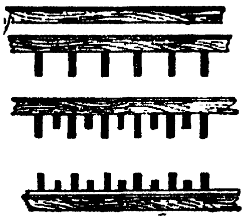


FIG. 6.

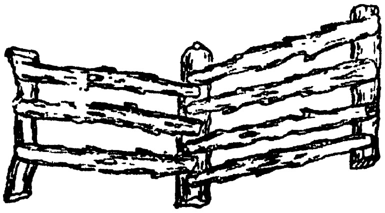
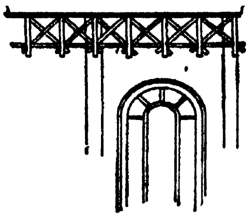


FIG. 4.



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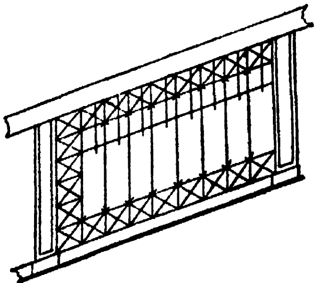


FIG. 7.

THE STONE MASON.

Gothic Windows, Figs. 1—7. Gothic Buttresses, Figs. 8—15.

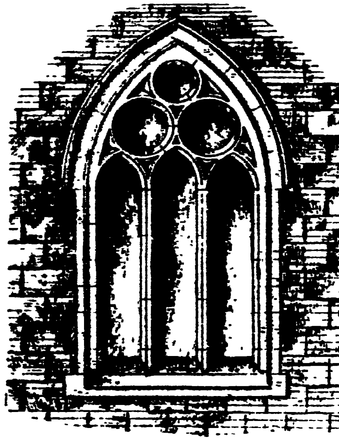


Fig. 1.

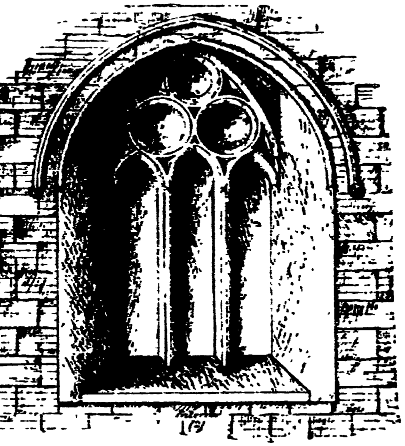


Fig. 2.

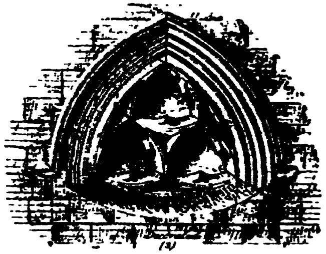


Fig. 3.

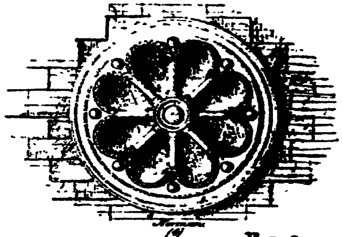


Fig. 6.

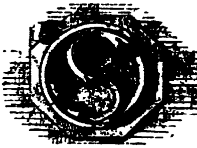


Fig. 4.

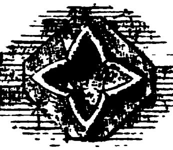


Fig. 5.

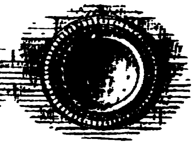


Fig. 7.

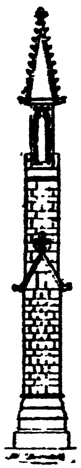


Fig. 8.

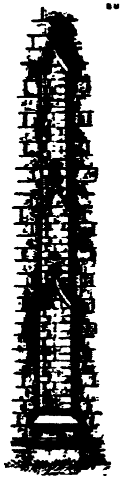


Fig. 9.

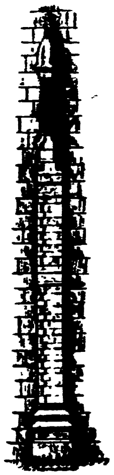


Fig. 10.

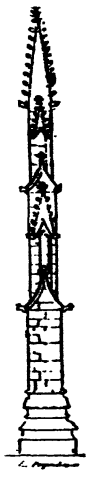


Fig. 11.

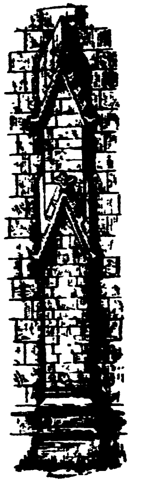


Fig. 12.

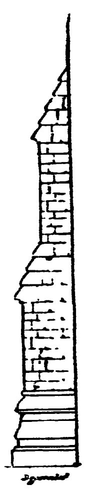


Fig. 13.

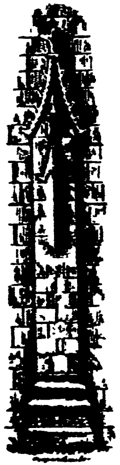


Fig. 14.

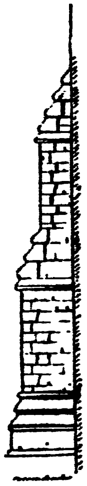


Fig. 15.

THE TECHNICAL STUDENT'S INTRODUCTION TO THE GENERAL PRINCIPLES OF MECHANICS.

LAWS AFFECTING NATURAL PHENOMENA—MATTER AND MOTION.

CHAPTER XXIII.

IN continuation of the description of the hydrostatic balance begun in last paragraph of preceding chapter, we point out that in order to restore the balance certain weights must be now put into the dish *b*, or what is obviously the same thing, so much weight taken out of the dish *a*. And this weight so added to *b* or taken out from *a*, in order to get a perfect balance with the body *b* suspended or immersed in the water in the vessel *g g*, when subtracted from the weight which the body gave when suspended in the air only, represents the loss which the body has sustained, so to say, by being suspended in the water; and which difference in the weight or loss is precisely the same as the weight of the bulk of water which the body *f* displaces. If, then, we take this weight—which is obviously the weight of the water displaced by the body—as a divisor, and divide the weight of the solid by it—that is, its weight in its natural condition when suspended in the air—we have then the specific gravity of the body, which shows how much heavier it is than water. Thus, if the body *f*, fig. 18, be a piece of gold, it apparently loses when in the water (in *g g*) one-nineteenth of its weight, thus showing that it is nineteen times heavier than water. The accurate specific gravity of gold is 19·53, that of silver 10·47; so that the body *f*, if of silver, would, when suspended in the water, apparently lose one-tenth, in round numbers, of its weight; or in other words the water would support or hold it up with a force equivalent to this, showing that silver was ten times heavier than water. We have said that in finding and stating specific gravities of bodies the standard of their comparison is water, distilled to be pure, and used at a given temperature; it is so used as a standard, as it may be considered as of uniform character everywhere, so that when we say that gold has a specific gravity of 19 (discarding decimals), silver of 10, etc., we in other words say that gold and silver, etc., are just so much heavier than their equal bulks of distilled water. If the bodies or substances are what we call light, such as cork, the specific gravity of which is ·25 or ¼, we then say that they are just so much lighter than their equal bulks of distilled water.

Specific Gravity (*continued*).—Bodies Lighter than Water.—Liquids.

Bodies which are lighter than water have their specific gravity ascertained by a modification of the method we have described as used in the case of bodies heavier than water. The body is first weighed in the air, as before, and then attached to the dish *b*, fig. 18 (*ante*); a piece of lead or other material easily adapted, not soluble in water, is attached to the body, and the weight of which is just sufficient to sink it till it—the body—is immersed in the water, with at least half an inch depth of water above it. This complete immersion, be it remarked here, is also necessary in the case of heavy bodies. The weight of the lead in the air is, of course, ascertained; and when it and the body to which it is attached are immersed in the water, the two together will be found to be lighter than the weight of the lead alone, which shows that the body is lighter than the water, and the difference put into the dish, as *a*, to obtain the balance between it and *a*, when added to the weight of the body weighed alone in the air, is equal to the weight of a bulk of water corresponding to the bulk of the light body. The specific gravity of liquids other than water, such as sulphuric acid—the sp. gr. of which is 1·87—is ascertained by the use of what are called specific gravity bulbs or bottles. Each bulb or bottle or vessel is made to contain precisely one thousand grains of distilled water. This is carefully filled with the water, so that none is left outside; the weight of the two—bottle and water—is accurately ascertained; and the bottle is then emptied and filled with the liquid, as in the case of an acid, of which the specific gravity is to be ascertained, and the two weighed: the difference between the weight of the bottle of water and that of acid denotes the specific gravity of the acid. If we have a ball or bulb of glass, which is known to lose when weighed in water any definite weight, such as one thousand grains—a number specially convenient in calculations—it may be used with great facility to ascertain the specific gravities of other liquids by simply immersing (as in fig. 18, *ante*) the bulb or ball of glass in the liquid the specific gravity of which it is desired to know; and the difference between the loss of weight of the bulb or ball when immersed and its normal weight is the measure of the specific gravity of the liquid into which it is plunged. For the loss of one thousand grains which the bulb or ball of glass sustains when weighed in water is obviously the weight of the bulk of water which the ball displaces. Bodies float in water when they are lighter than it, and the force with which they are supported or buoyed up is in proportion to the difference between their weight and that of the bulk of water they displace. The converse of this is also true, for a body heavier than the bulk of water it displaces will sink, and with a force proportioned as above to the difference. On this principle or law (see "The Boat and Ship Builder" for a full detailed explanation of the law of buoyancy, etc.) a method of ascertaining the specific gravities of liquids is based. This consists in having a series of glass bulbs of different specific gravities;

these may be made in sets or classes beginning with a low definite gravity and ending with a high one, each bulb being marked with its own specific gravity. If, for example, a bulb when thrown into a liquid, say an acid, is simply suspended in the fluid—that is, neither sinks nor rises or swims—the liquid is obviously of the same specific gravity as the bulb, and this is denoted by the figures marked on it, for the bulb is clearly balanced when in the liquid. If the bulb was heavier than the liquid it would sink in it, if lighter it would swim. Another bulb or other bulbs would have therefore to be tried, till the one was found which remained suspended, so to say, at any point, being equally indifferent to sinking or swimming, which would represent therefore the specific gravity of the liquid.

Specific Gravity (*concluded*).—The Hydrometer.

On this principle of buoyancy the apparatus used to ascertain the specific gravity of liquids, such as of spirits, solutions, etc., known as the "hydrometer" is based. This is shown in its elementary form in fig. 19. It will be seen that this dispenses with the beam and scales as in fig. 18, and is very easily worked. A vessel, *a a*, containing distilled or pure water, is used in which to immerse the glass bulb *b*. This is so adjusted in weight by weights, as *e*, which are suspended on the tail as shown, that the bulb floats in the water at a certain definite point. This is indicated in the stem *c* by a line or mark which is exactly coincident with the level or surface line of the water in the vessel *a a*. If then the apparatus be taken out of the water, and when dried immersed in a liquid of which it is desired to know the specific gravity, the bulb *b* will sink so low or swim so high that the water-level mark on the stem *c* will either be below or above the surface level of the liquid, according as it is heavier or lighter—that is, of greater or less specific gravity—than the water. To make the water coincident with the new liquid level, weights must either be taken from below, at *c*, or added to the dish *d*, and the weights when known give the comparative weights of equal bulks of water and of liquids.

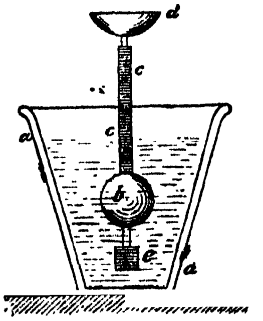


Fig. 19.

In a preceding paragraph we have referred to heat as the chief agent in the production of the phenomena, or the principal cause, of what is called repulsion. But there are other sources of repulsive power—though in reality heat is more or less concerned in their existence, and may be said to be the primal cause to which their varied phenomena are referred —which are usually considered, for obvious practical reasons, as independent. Gunpowder, gun-cotton, and explosive substances, are familiar examples; springs in the various forms used in the mechanical arts are other sources; while the most familiar of all our motive forces, so to call them—namely, steam—is the best known cause of repulsive power. Although in those examples, if we trace their operation back to the ultimate point, we find heat, as suggested above, as after all the primary source of repulsion, for in the case of steam we have to apply heat to the water which gives the vapour or gas which is the direct result of the repulsion of the particles, changing them from the liquid to the aerial or gaseous form. The peculiarities of steam as an elastic fluid or gas used as a source of energy will be explained in the series of papers "The Steam Engine User." In the case of gunpowder, gun-cotton, etc., it is the application of heat which in the first instance brings their repulsive powers into existence; while even in the case of explosive substances which are brought into active existence or force by "percussion" (for which term see succeeding paragraph in this section), heat may in one sense still be said to be the cause of repulsion, as the temperature is raised by the force of the blow. But if not in a strictly scientific sense correct, it is generally and for obviously convenient purposes held that those bodies above named are, in addition to heat, well known and recognised sources of repulsive power or causes of repulsive force.

Attraction and Repulsion the two great Forces which control the Action of Physical Phenomena.

two principles or properties of bodies of attraction and repulsion constitute in reality the only two forces by which all the phenomena of nature existing around us are brought into existence and displayed and maintained in action. In view of the almost infinite variety of those phenomena, the reader may have some difficulty in quite seeing the truth of this statement. Even with the comparatively limited range of facts of existence brought to him by observation he will at first have a difficulty to perceive how such a vast number of phenomena, apparently of such different kinds, can be brought into existence and maintained by two causes or forces only. Thus, he would be apt at first sight to say that of motion, rushing wind or flowing water were two sources of power or two forces *per se*, or acting by and (so to say) for themselves. But if he will duly consider those, and the results of their action, he will at last discover that they, as well as other so-called sources of power or forces which he may think of, come under one or other of the two forces of attraction and repulsion. The phenomena even of that potent yet mysterious power known as electricity—which is the name we give to a something of which as to what it really is we know absolutely nothing—come chiefly, if not wholly, within the range of these two forces. Seeing this the dual condition of all forces acting upon bodies, and as they must be either under the action of attractive or repulsive forces, there must always be two bodies or masses, or if we go back to the ultimate atoms, two particles or two atoms, concerned in all the actions of those forces. It follows, therefore, that a mass will either be attracted or repelled to the same extent, or be acted upon with the same degree of force, as the other; or in other words, that where one force, as attraction, exists, there must be in existence, or be brought into existence, the other force or that of repulsion.

Action and Reaction Equal and Opposite.

Every movement, then, caused by one force has the opposite or converse movement caused by the other force; or, to use the popular phrase, as one acts the other reacts. And the scientific axiom which defines or states this law or principle uses those same words, for the law is given thus: "Action and reaction are equal and opposite," or "contrary." This important law is exemplified in a vast variety of ways in daily life, and lies waiting for the examination and so to say analysis of the reader. When the hand comes forcibly and by accident or immediately in contact with a table or other hard body, it is literally true that both are equally "hurt," using this term as an expression of the result of the force; the table receiving precisely as much of the hurting power as the hand—although it is of course only the hand which is said to be hurt in the sense of feeling the result of the blow or collision or concussion. Here the action and the reaction are equal. So also, in the case of a canoeist with his paddle, the canoe is propelled or pushed forward through the water with precisely the same velocity as the water is pushed backwards by the paddle. We have here also action and reaction equal and contrary or of the opposite character, the forward being met with the backward motion. The same is true of the propelling action of the paddlewheel and the screw; so also of that other method of propelling vessels which has so often come to the front, but which, notwithstanding the apparent and we might say the actual success of the trials, has nevertheless taken no permanent place in the list of our marine water motive powers. We refer to what is known as Ruthven's hydraulic motor, from the name of its inventor—the inventor also of the well-known printing and screw copying presses. The principle of this is exemplified in a vessel or receptacle of water placed on the end of a body floating in water, as a small toy boat: if the water be allowed to flow out from the receptacle in a stream or a jet towards and over the stern of the boat, the boat will be propelled forward through the water in a direction contrary to the backward motion of the water jet. Ruthven applied the power of a steam engine to the production of a jet or stream of water, and in later modifications to the production of two jets, one at each side of the ship; and by the ingenious arrangement of the nozzle pipes through which the jets were passed, motions of different kinds could be produced in a ship —backward or astern, forward, and turning motions. The same principle is exemplified in the well-known motive power or motor known as the "turbine"; indeed — as if in direct allusion to the law we have quoted—in certain forms of it called the "reaction water-wheel." And the principle or law is further exemplified by suspending by an elastic cord a circular vessel full of water (the taller or deeper the vessel the more clearly will the result be made evident), and boring a hole in the side obliquely or tangentially in its circumference. The passing of the jet of water through the hole or through an oblique pipe fixed to it will cause the vessel to rotate, and its suspending cord to be twisted. The turbine is in its simplest elements thus exemplified. In these examples, while the "action and reaction are equal and contrary," there is a loss of the power resulting from certain causes which will be found noticed in any work treating of hydraulic mechanics.

Action and Reaction equal (*continued*).—Exemplification of this Law or Principle.

While we thus, in virtue of this principle or law of action and reaction being always equal and opposite, can obtain motion by the passing of a jet or of jets of water issuing or passing out in directions opposite to that in which the motion is created, we can also produce the same or similar phenomena by the use of air or a gaseous fluid. One of the earliest forms of the steam engine—that invented centuries ago by Hiero of Alexandria, and known as the "ælipile"— depends for its action upon issuing jets of steam. The apparatus takes the form of a hollow ball suspended on and capable of revolution round an axle, two pipes with heads or jets bent in opposite or contrary directions being secured to opposite ends of a diameter of the globe. This being filled with water, and heat applied below, as the water boils and steam is produced, it issues from the jets, and by their reaction causes the globe to whirl and revolve rapidly round its axis. So direct a method of applying steam to the production of a motion of rotation has prompted many inventors to produce modifications of Hiero's contrivance, which would be effectual as "prime movers." The reasons why they have generally, or as one might almost say universally failed, may, if space permit, be glanced at in a succeeding chapter.

Action and Reaction (*continued*).—Velocity of Bodies in Motion. —Examples from Practice.

While "action and reaction are always equal and contrary," the velocities of moving bodies under this influence are not equal but in proportion to the masses. Where the body appears to be and is popularly supposed to be stationary, it is in reality in motion, although the mass is so great that in relation to the other or lesser body the velocity of motion is so minute that the eye cannot perceive it. This may be exemplified by a familiar illustration: that of a man in an empty railway truck connected to one loaded heavily in advance of the other, pulling himself, or rather the truck in which he is, towards the loaded truck. The empty truck being so much lighter, has a motion given to it by his bodily force, exerted through the medium of the rope, of such a velocity that its movement along the rail is distinctly observable to the eye, so that it appears to the unthinking spectator that it is only it—namely, the light truck—which is moving, whereas the heavier truck is actually being moved also, and at the same time as the light one. But its motion is in proportion to its weight so small that the eye cannot take it in. That the man in the light truck is actually moving the heavier one may be proved by considering the circumstances to be so changed that the weight of the heavy truck remains the same—say, that which requires a force equivalent to 5000 lb. to overcome it. The pulling power of the man on the rope we suppose to be represented by a force of 1000 lb. If somehow the man could increase his power five times, or—what would be the same thing—if five men were placed in the one truck, each capable of exerting a force of 1000 lb., the two trucks would then approach each other at equal speeds, and thus meet at a point midway between the points at which they originally stood before the pulling force in one was created or put into operation. The same is exemplified in the case of two boats placed at a certain distance from each other, with a man in each, and each taking hold of the end of a strong rope. If the boats are of equal size and weight, and the pulling force of each man equal, it is obvious that the boats would simply stand still. But if the weight were greatly unequal, the stronger man in the lighter boat would apparently move his boat towards the other, while in reality both boats would be approaching each other, but with a velocity proportioned to the weight. The velocity of the slower-moving boat would be made greater, and its motion more easily discernible, if the weights and pulling forces were not so very unequal; and the more they approached a condition of equality the less difference in proportion would there be between the two velocities. Under all the conditions above stated, while the action and reaction would be equal and opposite, the velocities of motion would vary just in proportion to the masses So that it is quite true—what some seem to think a paradox or an impossibility—that a man in jumping from the surface of the ground, while by the muscular force of his body he raises himself from the earth, actually kicks the earth away from him. Of course the difference between the masses is so enormously great and the motion of the earth so infinitely small that it is said to exist only in the man. The repulsive force of gunpowder acting on a cannon ball projects it with an enormous velocity forward; but the momentum in the cannon itself tending to push it backward or to recoil, is the same in amount. But the difference between the mass of the cannon itself and the ball is so very great that the motion of the cannon is slight, the momentum having to act through so much greater an amount of atoms or particles. But the "recoil" so called is, notwithstanding, sufficiently great to produce a certain motion or power. And this is quite powerfully felt in the case of a rifle fired out from the shoulder, but still at a point a short distance from it: the force of the shock is the measure of the force of the recoil or momentum of the rifle backward, which is the same as the momentum of its ball forward. If an elastic spring, as of steel or indiarubber of a certain form, be placed so as to act upon two masses simultaneously, the force of the expanding spring will send or drive the masses in opposite directions at equal velocities, if each be of the same mass or weight. If this be unequal, the velocity or speed of the lighter or smaller will be greatest, and that in proportion to the difference between the two masses. The spring acts as a force by virtue of its "elasticity," the bending of it into the desired form required—and which bending takes a certain force applied to it—storing up, as it were, within the spring this force which is given out, and the force so given out being equal to the force which was required to give the spring its bent form. We have just now used certain terms, which it will be required here to explain, on account of their general utility to the mechanic, and because they will enable the youthful student all the more clearly to understand the further phenomena of action and reaction. Those terms are

Elasticity.—Recoil.—Resiliency.

On first approaching the subject, the reader, presuming that he has hitherto considered it in the popular or general way, will have no difficulty in his own mind as to what an elastic body is as compared with one not elastic.

THE STEAM ENGINE USER.

THE DIFFERENT CLASSES OF ENGINES USED CHIEFLY FOR MANUFACTURING AND AGRICULTURAL PURPOSES.—THE LEADING DETAILS OF STEAM ENGINES—CONSTRUCTIVE AND OPERATIVE.—THEIR PRACTICAL WORKING AND ECONOMICAL MANAGEMENT.

CHAPTER XVII.

AT the end of last chapter we gave a sketch of the double-beat valve (see fig. 38, p. 121), of which we now give this brief description. The valve, as its name implies, consists of two circular discs very similar to the disc valve of Watt, just mentioned. The two discs are so arranged that the same spindle carries them both. If we suppose steam to be passing in the direction of the arrows, there is just as great a tendency for the pressure to raise the upper valve as there is to keep the lower one on its seat—that is, assuming that the areas of the two discs are equal. The only power, therefore, required to lift the valves by means of the levers and rods outside the valve-box is just what may be sufficient to lift the weight of the valves, and also to overcome any friction in bearings and joints.

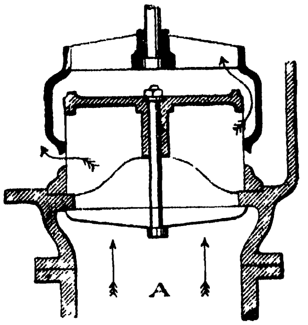


Fig. 39.

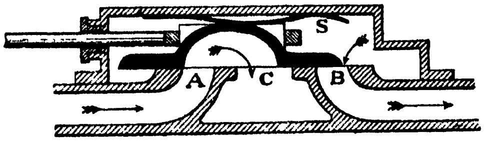


Fig. 40.

Another form of the double-beat valve is shown in fig. 39. This valve is very extensively used, and is sometimes called a Crown valve. It consists of a hood or cover resting upon two seats. Steam is supposed to be entering at A; and as the valve (shown in black outline) is raised off its double seat, the steam passes on either side in the direction of the lower arrow between the lower faces of the valve and seat, or in the direction of the upper arrow between the upper faces. The tendency to rise or fall in this valve is just as in the previous one—the pressure being uniform in both directions; there is therefore only the weight of the valve and the friction to be overcome.

The most common valve now in use is the slide valve, or D valve; and instead of being raised or lowered on its seat a sliding motion is given to it, which has the effect of opening and closing alternately the two ports A and B (fig. 40), in such a manner as to connect them in turn with the exhaust port C. The valve itself is shown in solid black section. Fig. 41 shows the valve in the other extreme position. A spring insures the valve keeping on its seat. In plan the valve is rectangular in form, and is secured to the valve rod by means of a "buckle" which encircles it. When the valve is in the position shown in fig. 40, it is clear that steam will pass from one end of the cylinder along the passage A, underneath the valve and into the exhaust port C. At the same time a fresh supply of steam from the boiler is admitted through the open port B, along the passage, and into the steam cylinder at the other end. In fig. 41 the order of things is reversed, for we find the steam being exhausted from B into C whilst fresh steam is entering at A.

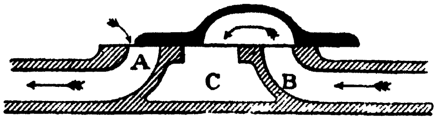


Fig. 41.

Passing on from this form of valve, it may be well to describe the throttle valve here, which was referred to in connection with the governor. This valve was invented by Watt, and is exceedingly simple in its action and construction. It consists merely of a plate turning on a spindle, and is illustrated in fig. 42, where it is shown open by the full lines, and closed in dotted outline. It will be easily seen that this valve is in a state of equilibrium in whichever direction the steam may happen to be passing. If we assume that steam is passing in the direction of the arrow, there is precisely the same area of surface exposed to the pressure of steam above the centre of the spindle as there is below it; hence there is just as great a tendency for the pressure to close the valve by forcing it into the vertical position shown by the dotted lines as there is to keep it wide open, when it would assume a horizontal position. On the spindle of this valve is keyed a lever, L, to the extreme end of which a rod, A, is attached. This rod is connected with the slide of the governor, and as the engine moves too rapidly, the governor, as we have before explained, rises, so to speak, and though the rod R partly closes the throttle valve, diminishing the supply

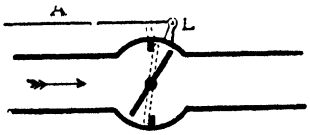


Fig. 42.

of steam to the cylinder, which of course has the effect of lessening the speed of the engine. Then if the engine be running too slowly the reverse action takes place, and the throttle valve is opened wider and wider, till the engine assumes its regulation speed.

The *eccentric* consists of a disc, and this is so attached to the crank-shaft of the engine that the centre of the one does not coincide with the centre of the other: the distance between the two centres represents the so-called "throw" of the eccentric. Around the eccentric is fitted a strap—to which is attached the eccentric-rod—leading more or less directly (according to the form of the engine) to the valves which regulate the admission and exit of steam to and from the piston. As the shaft revolves, it carries the eccentric round with it, and at the same time gives to the eccentric-rod a reciprocating motion, which in its turn gives a corresponding amount of travel to the valves.

In the accompanying illustration, fig. 42, S is a section of the crank-shaft, with the eccentric E keyed on it. The eccentric is usually made in two parts, and firmly bolted together when fixed on the shaft.

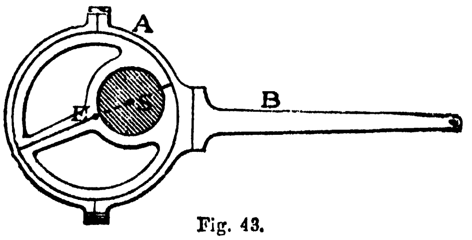


Fig. 43.

This is encircled by the eccentric-strap A, also made in two pieces, with keys for convenience in bolting together, as shown in the drawing. To one of the halves of the strap is attached the eccentric-rod B, connected at the other end of which are the levers leading to the valves. It will be at once seen, on referring to the drawing, that the shaft and the eccentric are not *con*centric with each other—that is, their centres, S, E, are not identical—and that if the shaft be made to revolve, the eccentric must revolve with it; and as their centres are not concentric, so the rod B must travel a distance backwards and forwards equal to twice the distance the two centres E, S, are apart; and as the disc is keyed on the shaft slightly in advance of the crank, the motion thus imparted to the valves admits the steam to the piston just as the latter is at one or other end of the cylinder, and in time to act upon it at the right moment, at the same time the exhaust port is opened to allow of the escape of the steam which has just completed its work of pushing the piston to its present position.

The Condenser.—A very important improvement in the steam engine, effected by Watt, was that of a separate condenser. Watt had previously worked an engine in this way. The steam having been admitted to the under side of the piston till the latter was raised to its fullest extent, the supply of steam was shut off, and a jet or spray of cold water forced into the cylinder, which had the effect of suddenly cooling the stream, thereby condensing it, and as a matter of course causing it to contract in volume or bulk, so that a vacuum was at once formed. This sucked the piston down to the lower end of the cylinder; then the water of condensation was allowed to run off, and a fresh supply of steam admitted to raise the piston to the upper end of the cylinder once more. This constituted a single-acting condensing engine. In order to make clear the effect of the sudden condensation of steam, a simple experiment may be here described. Provide a tin canister with the lid soldered on, fix a small tap at one end, and put a small quantity of water inside. Hold the canister with the tap open over a flame till the water boils, then shut the tap and suddenly plunge the canister into cold water: this will cool and condense the steam to such an extent that the canister—unless it be a very strong one—will collapse, owing to the formation of a vacuum caused by the condensation of the steam. In the case of the steam engine, as the cylinder is made too strong to collapse in this way, the piston is drawn down instead, and with a force sufficient to move the working parts of the engine with it.

Whilst experimenting with the condenser Watt conceived the idea that it would be much more economical to condense the steam in a separate vessel, away from the working cylinder; for he saw that to cool the cylinder by injecting cold water had the effect of partly condensing the steam when it ought to be kept as hot as possible,—and *vice versâ*, the cylinder was so heated by the hot steam that when the cold water was injected into it a considerable time elapsed before the condensation began to take place, and really at the end of the stroke the vacuum was far from the state of perfection that could have been desired. Watt thereupon contrived to have a separate vessel placed below the working cylinder, connected to it with a pipe of large diameter, in order that steam might pass from the cylinder to the condenser as quickly as possible.

Fig. 44 is a section of the lower parts of a beam engine with a separate condenser. A is the working cylinder with its piston B. It will be noticed that a double-acting engine is here shown—that is, steam is admitted to both sides of the piston alternately, as is also the process of condensation—so that whilst steam is exerting its force upon one side of the piston to force it up or down, condensation is assisting by pulling on the reverse side of the piston.

THE BUILDING AND THE MACHINE DRAUGHTSMAN.

CHAPTER XVIII.

WHERE "shadows" are not given in views or projections, their effect is obtained, as we have above stated, by the use of what are called "shade lines"; and this in a way which enables an expert to know what part of an object projects and what part recedes or is hollow in the general surface of the drawing. And those "shade lines" are dependent upon the same principle which defines the outline of a "shadow" as in diagram D, fig. 1, Plate CLXXVI., in which the light comes and is cast upon the object in the direction of the arrows *d* and *e*.

This principle, upon which the projection of "shade lines" in drawings depends, is directly illustrated in fig. 2, Plate CLXXVI., in which *a* and *b*, diagram A, represent the directions in which the light is projected upon an object, corresponding to the directions *d* and *e* in fig. 1. From the square surface or superficies given, at *c d e f* in diagram A, fig. 1, Plate CLXXVI., it would be difficult for a spectator to decide whether the draughtsman designed this to represent the outline of a solid square lying on the surface of another part, and therefore projecting above it; or whether the square was intended to represent a hollow or rather a recessed part—a depression in the general surface. In all the diagrams in fig. 2, Plate CLXXVI., and those in fig. 3, Plate CLXXVI., and fig. 35, the general surface, upon which the objects represented are supposed to be lying or standing, is shown by the cross or hatched lines surrounding the drawings or projections of the objects. But if to the pure outline of square, as *c d e f* in diagram A, fig. 2, Plate CLXXVI., drawn in lines of uniform thickness or breadth—the draughtsman added a thick line, as at *b c* in the lower side, and another thick line in the right-hand side, as *c d* in diagram B, then an expert in plane projection would at once understand that the square *c d e f*, conveying in diagram A no definite idea of its peculiarity, was, as shown in diagram B, a solid object projecting from or lying upon the general surface—indicated by the cross or hatching lines. This object in elevation, as seen when looked at in the direction of the arrow *e* in diagram B, would be as in diagram C; and in section, taken on the line *f g*, would be as in diagram D. Those thick, or to put it more correctly, those broad or wide lines, *b c*, *c d*, in diagram B, are the resultants of the two directions in which the light is supposed to proceed to or be cast or projected upon the object, one of them being at the angle of 45°, that represented by the dotted lines *b* and *j*; the other vertical, represented by the lines *k*, *l*; both of these corresponding to arrows *a* and *b* in diagram A, and to *d* and *e* in diagram D, fig. 1, same plate. In like manner the "shade lines" are given to the elevation in diagram C, and to the section in diagram D, as shown at *b*, and *a b*, *b c* respectively.

But if to the equal-lined square in *c d e f*, diagram A, the draughtsman added broad or wide, or to use the common but erroneous expression, thick (or deep) lines at the side *a b* in diagram E, and another broad line at the side *a c*, then the expert would at once know that the square, which at *c d e f* in diagram A gave no idea of its true peculiarity, was, in fact, the outline of a recessed part, or depressed below the general surface indicated by the cross or hatching lines. This, shown in section taken on the line *d e*, would be as in the diagram F, while *a a* represents the general surface of the recessed or depressed part. In those diagrams the directions in which the light is cast upon the object are shown by the dotted lines corresponding to that at *b*, parallel to *a c* and *k l* in diagram B.

The pupil should now be able to understand that the equal-lined hexagonal-formed surface in diagram A, fig. 3, Plate CLXXVI., when broad-lined—or to use the technical term employed in such cases, "shade-lined" or "shadow-lined"—as in diagram B, represents a solid object lying upon or standing up from a general flat surface indicated by hatching lines or shaded part outside. On the other hand, when shade-lined as in diagram C, he should know that the object, as in A, shows in C a recessed part, or one which is depressed below the general surface. Again, if the objects in diagram D, which, as projected, give no idea of their true characteristic, be shade-lined as in diagram E, the pupil will know that the part *a b c d* projects from or is lying upon the general surface; while the part *e* in its turn projects in like manner from the surface of *a b c d*. This is indicated in the cross or transverse section in diagram F, which is taken on the transverse dotted line in diagram E; *a a* in F being the line of general surface which the objects *a*, *b*, *c*, *d* and *e* in diagram E lie upon or project from. On the other hand, if the equal-lined diagram in D be "shade-lined," as in diagram G, then the pupil should now be able to "read" the drawing in this, so that he knows that the part *a b c d* in diagram D is recessed, as in diagram G—letters corresponding—while the part *e* in D projects from the surface of the recessed part, as at *b*. This is shown in cross-section—taken on the line *f g*, in G—in the diagram H, *a a* in which is the line of general surface—*b* being the part marked *e* in G, *c d* the hollow or recessed part. In diagram I both *a b c d*, and *e* in diagram D are recessed or depressed; as shown at cross-section of I on line *b c* in the diagram at J, in which *a* is part corresponding to *e*; *b c* to *a b c d* in diagram D, *d e* being the line of general surface.

Coming now to the application of "shade lines" to "circles," we have, in fig. 35, several illustrations showing this. Thus, the circle in diagram A, described on the general surface—again indicated by a shaded part—gives no indication of the character of the object of which A is a projection. But if a shade-line, as extending from *a* to *e*, be given to the circle, as in diagram B, then the pupil is to understand that the circle represents a circular body, as a disc or "flange" lying on or projecting from a general surface, as shown in the diagram A in fig. 36, which is an elevation of diagram B in fig. 35 as seen when looked at in the direction of the arrow *d*. If, on the other hand, the "shade-line" is applied to the circle on the side opposite to that to which it is applied in diagram B, fig. 35, as at diagram C in same figure, then the pupil is to understand that the projection of the circle in C represents a circular hollow or part depressed below the general surface. This is shown in diagram B, fig. 36, which is the projection of a cross-section of C in fig. 35, taken on the line *d e*, and as seen when looked at in the direction of the arrow *f*.

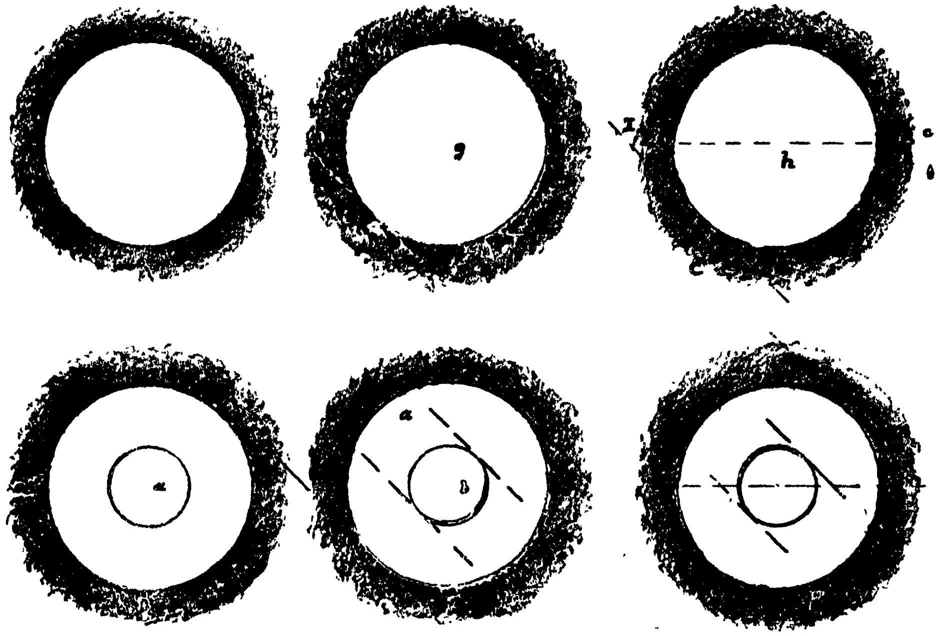


Fig. 35.

It will be observed that in diagrams B and C, fig. 35, the shade-lines *a b c* are not of uniform breadth or thickness, as in the shade-lines of right or straight-lined projections, as given in figs. 2 and 3, Plate CLXXVI. In the shade-lines of circular projections, as in fig. 35, the thickest or broadest part is as at *b*, midway between the two extremities, *a* and *c*. These extremities in all cases occupy a definite position, and which is obtained by drawing the lines, shown dotted, at an angle of 45°, touching the sides of the circle. Or the diameter *a e*, in diagrams B and C, fig. 35, may be drawn through the centres at *g* and *h*, those diameters being also at an angle of 45°. The dotted lines 1 2, 3 4, correspond to the lines *d*, *e*, in fig. 1, Plate CLXXVI., and *j* in fig. 2, Plate CLXXVI.; and, as they represent the direction in which the side rays of light are cast upon the object, they may be called "ray lines." It will be observed that the shade line in diagram B, fig. 35, gradually narrows, or thins, or "shades off" from the broadest part at *b* to the points *a* and *e*, where the "ray lines," 1 2, 3 4, touch the circles, or cut the diameters *a*, *g*, *e*, at *e*. In the diagram the part *b* is the deepest shadow cast by the ray lines, the part opposite to this being nearest the light, and, of course, not in shadow at all; hence, as the shade lines *a*, *b*, *c*, approach the light side *i*, its breadth gradually decreases till it "dies away" into the light. Conversely, the shade line at *a b c* gradually broadens or gets thicker as it recedes from the light side to the dark side of the projection.

Taking now the other projections in fig. 35 not yet noticed, the diagram in D gives no indication of what the projection is, further than that it shows two circles described on the same general surface from a common centre, *a*, and therefore concentric to one another. But by giving the shade lines, as in diagram E, the pupil should now be able so to "read" this projection that he understands at once, on looking at it, that the larger circle in diagram D represents in diagram E the projection of a flat circular disc or flange lying upon or projecting from the general surface; while the smaller circle in diagram D represents a "print" or circular body, *b*, diagram E, lying upon or projecting from the surface of the part *a a*. This is shown in the elevation in diagram C in fig. 36, as seen when looked upon in the direction of the side E in diagram E, fig. 35. In the diagram F, in same figure, the shade lines given to the two circles—as in diagram D—indicate that the large circle is a depression or recessed part, while the small circle is also a recessed part or depression in the general surface of the large recess. This is shown in the cross-section—taken on the line *a b*—in the diagram D in fig. 36, as seen when looked upon in the direction of the side F in diagram F, fig. 35.

The preceding paragraphs are devoted mainly to brief explanations of the elements of shading as applied to plane projections of various objects, by which their peculiarities of form can be rendered more easily comprehended than when the projections are given in pure outline only. Although these details are chiefly elementary, they are so designed and arranged in what may be called the natural sequence of their application, as to convey to the pupil a fair conception of the leading principles of this important department of architectural and engineering drawing. By a careful study of the diagram given in illustration of those principles, the pupil should have no difficulty in applying them to a wide range of practice in the art the various branches of which he is about systematically to study.

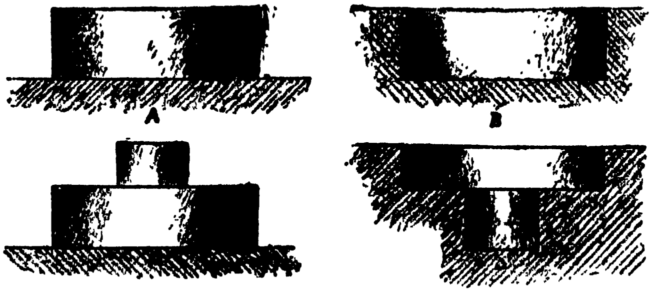


Fig. 36.

What has been given in the preceding paragraphs on the subject of shading and of shade lines—by the use of which, as there shown, what may be called the solid features or peculiarities of objects delineated in plane projection are made much more easily comprehended than if the delineations were in pure outline—might have been relegated to a later chapter in the present series. It has not been, however, without a distinct object in view that the author of this series determined to place his remarks on this subject in that part which it now occupies. For while those remarks and illustrations as given have a special reference to the practical utility of shading and of shade lines, they illustrate directly certain points connected with the projection of the objects which are more easily understood when the two subjects are taken in conjunction. While, therefore, they may appear at first sight to be an interpolation, or might have been given appropriately at a later period in the consideration of the general subject of our papers, the remarks and illustrations have a direct bearing on the subject of plane projection, and carry the consideration of its principles and the illustrations of its practice regularly forward, giving place in due sequence to the various points as they come up for treatment.

We therefore proceed now to illustrate the further practice of the art; taking the projection of a hexagonally formed body of which the plan is given in *a b c d e f* in fig. 1, Plate CCXIV.

There are obviously two views in elevation of this, unlike each other in appearance. The one is seen when looked at in the direction of the arrow 8, and is shown at *g h i j*; the other is seen when looked at in the direction of the arrow 7, shown in elevation at *n t u v*. To obtain the view of elevation *g h i j*, draw any line *h i*, at right angles to either of the sides of the hexagon, as *b c* or *e f*. From points *h*, *i*, draw perpendicular lines as *i j*, *h g*, and make these equal to the distance 1 2, which is the height or depth of the object in plan at *a b c d e f*, and through *j* draw a line *j g* parallel to *h i*. This completes the elevation of the object as seen from the direction of the arrow marked 8. But this projection in elevation can be obtained directly by simply producing the lines *b c*, *f c*, or *a d*, projecting the points *c*, *d*, *e*, as to *i* and *h*, drawing at any convenient point below *d* the line *i h*, making *i j* equal to the given height as 1 2, and drawing *j g*. In like manner the other elevation, or that as seen when the plan in *a b c d e f* is looked at in the direction of the arrow 7, or in the opposite direction, may be obtained, by producing lines from points *a*, *f*, *e* and *d*, at right angles to the line *e f*, cutting any line *n o* parallel to *e f* Make *n t* equal to the distance 1 2 or *i j*, and draw *t u* parallel to *n o*. It will be observed that a square part with an internal circle is placed in the centre of the plan in *a b c d e f*, as at *q p*. This is shown in the two elevations at *l m*, *r s*, but in two positions or different views. Those parts are projected in the same way as described by projecting from the points of part *p q* lines—as shown dotted—to the two elevations, the height of this part being as in the diagrams. The elevation as at *n o t u* is shown shaded at *u′ v w*; and a section on the line *a d* is given at *x*. If the object was looked at from the direction shown by the arrow 11, which direction is at right angles to a line, as 9 10, passing through the opposite angles *b*, *c*, the projection of that elevation would be the same as at *n o t u*, or *u′ v w*. This will be evident if lines at right angles to 9 10 be projected, formed from the points *b*, *a*, *f*, *e*; cutting any line, as *y z a′ b′*, parallel to 9 10; for if those distances, as *y z*, *z a′*, *a′ b′*, be measured, they will be found equal to the distances *n n′*, *n′ o′*, *o′ o*.

In fig. 2, Plate CCXIV., we give at *a b c d e f g h* the plan of an octagonal block, the height of which is equal to the line 1 2. It will be seen, as in the case of the last projection, that one elevation, as *i n o m*, will only be required if looked at in front of any of the five points *c*, *d*, *e*, *f*, *g*, in the direction of the arrow 3, and at right angles to the lines joining the opposite points in the direction of the lines *c g* or *a e*, *d n* or *b f*; and this because all the sides and all the angles are equal measured from those points. The other view is an angular one on the line *b f*, looked at in the direction of the arrow 5 at right angles to *b f*; this view is obviously the same as that where the plan is looked at in the direction of the arrow 4. To obtain the view at *n i m o*, lines are produced from the points *c*, *d*, *e*, *f* and *g*, parallel to *a e*, and cutting any line *i m*, as shown, *m o* being made equal to distance 1 2, and a line drawn through *n* parallel to *i m*. To obtain another elevation, as at the side *e g a*, draw the line *p t*; and at right angles to it from the points *a*, *n*, *g*, *f* and *e*, project lines cutting *p t* in *p*, *q*, *r*, *s* and *t*. Make *p v* equal to *i n* or 1 2, and draw *v u* parallel to *p t*. It will be observed that in the plan *a b e*, etc., there are two circles, as 6, 7: those indicate the form and the position of two holes or apertures in the block. Those pass through the block from top to bottom, and are shown to do this in the cross section on the line *a e* in the diagram at *w x*. This sectional view can be projected from the view in *i n o m* by carrying across the lines from *o* and *m*, as at *l′ m′*, and thereafter putting in the lines taken from *i j k l m*. But by making the sectional projection below the elevation in *i no m*, the drawing would be obtained in a quicker way. For the points *i*, *j*, *k*, *l*, *m*, would be obtained by simply producing the lines, as *i n*, *o m*, etc., to cut any lines drawn below and parallel to *i m*, making the vertical height from this line equal to 1 2 or *i n* or *m o*. The elevation obtained by looking at *a b c*, etc., in the direction of the arrow 5, will obviously be the same as the elevation at *i n o m* or *p t u v*. For if at right angles to the line *b f* we project lines from the points *b*, *a*, *h*, *g* and *f*, cutting any line as *t′ p′*, we obtain the distances on that line which would be equal to those on the lines *i m* or *p t*. Thus *p′ q′* is equal to *p q*, *q′ r′* equal to *q r*, *r′ s′* to *r s*, and *s′ t′* to *s t*.

Projections on angular lines are often required: thus, on referring to fig. 33, p. 95, the reader will see a line, as *h o* in diagram B, drawn from the corner *h* to corner *l*. The elevation of the block as seen from a point at right angles to this line, as in the direction of the arrow 6, will show the lines, as in fig. 3, Plate CCXIV. Those lines at right angles to the base line *h o* are obtained thus. In diagram B, in fig. 33, p. 95, place the set-square of 45° on the line *h o*, and sliding it carefully along so that the side of set-square will continually coincide with the line *h o*, draw along its perpendicular, at the points *i*, *j*, *k*, *l*, *m*, lines cutting the line *h o* in the points *r*, *q*, *p* and *o*. Draw now any line of indefinite length, as the line *h o* in fig. 3, Plate CCXIV.; and assume any point on it, as *h*, to represent point *h* in fig. 33, p. 95. From *h*, in fig. 33, take the measurements *h o*, *h l*, *h p*, etc., successively, and set them off from the point *h* in fig. 3, Plate CCXIV., to the points *l*, *p*, etc. These points thus obtained will correspond to points similarly lettered in fig. 33, p. 95; and if, lines, as *h i*, *o j*, be drawn at right angles to *h o*, these will represent the lines of the elevation of the object in fig. 33, p. 95, as viewed in direction of the arrow 6, or at right angles to the line *h o*.

When the view of the object on an angular line is to be given in conjunction with or on the same paper as the usual elevation is drawn, the points of the angular elevation or plan may be transferred from the elevation or plan by the method illustrated in fig. 4, Plate CCXIV. Let *a b* in this be the base line of an object or body shown in elevation at *a d c b*. Let *h i* be the line oblique to *a b*, on which the oblique elevation corresponding to *a d c b* is to be drawn. The points corresponding to *a e f g b* can be at once transferred to the line *h i* by placing the point of the compasses in the point *h*, and extending to the points *b*, *g*, *f*; successively sweep round as shown by the dotted lines, till they cut the line *h i* in the points *j*, *k*, *l* and *m*. By drawing from these points lines at right angles to *h i*, and making *m n* equal to *b c*, and drawing *n o* parallel to *h i*, the oblique view of *a d c d* is obtained as shown. If the line were *h p*, the same method would obtain, the view on it corresponding to *a d c b*. The dotted arcs of circles shown in the diagram do not require to be put in, in projecting the drawing; they are only shown to indicate the direction in which the distances are swept round by the compasses from one line *a b* to the other line *h i*. This method of transferring distances from one line to another is useful in many projections or working drawings.

THE CALICO PRINTER.

THE CHEMISTRY AND TECHNICAL OPERATIONS OF HIS TRADE.

CHAPTER XV.

Salts of Chromium (*continued*).

Acetate of Chrome, $Cr_2(C_2H_3O_2)_3$, is extensively employed for fixing logwood black, as it yields a colour of finer shade and faster than iron. It is also used as a mordant in other cases, especially in the new colouring matter *Gallocyanine*, or Fast Violet. The commercial liquor usually contains sulphates of chromium and of potassium. It is obtained by an action analogous to that by which we obtain red liquor—by the decomposition of lead or lime acetate with chrome alum.

The salts of chromic acid—yellow chrome and bichrome—have already been described.

SALTS OF TIN.

Tin Crystals, Protochloride of Tin ($SnCl_2 + 2H_2O$).—This compound is employed as a mordant in berry yellow and other colours; mixed with the mordants for dyed alizarine red; as a discharge and resist, for making acetate of tin, and other purposes.

It occurs in commerce in the form of small sharp silky white crystals, readily soluble in 10 parts of pure water without turbidity. They contain, when pure, 52 per cent. of metallic tin, but are subject to various impurities and adulterations.

"Single muriate of tin" is a solution of tin crystals; when of good quality it should contain 11 or 12 per cent. of tin and a small quantity of free hydrochloric acid.

"Double muriate of tin" is simply a concentrated solution of tin crystals with a little free hydrochloric acid, and containing about 25 per cent. of tin.

Perchloride of tin, Oxymuriate of tin (Sn_4Cl_6).—This liquid is occasionally used as a mordant. It fumes in the air. It is prepared by adding nitric acid to tin crystals in sufficient quantity to convert this salt into the per-salt; also by dissolving tin in nitro-hydrochloric acid.

Stannate of Soda, Tin Salts ($Na_2SnO_3 + 4H_2O$), is employed in preparing cloth for steam colours. The cloth is run through a solution of the salt, dried, and then passed through dilute vitrol. The oxide of tin, or stannic oxide, is thereby deposited in the fibres of the cloth.

Commercial stannate is of variable composition; it should contain about 22 per cent. of the oxide.

Acetate of Tin is occasionally employed as a mordant, and also for reducing Indophenol for printing. It is usually prepared either by adding acetate of soda to tin crystals or by dissolving stannous oxide of tin in acetic acid.

SALTS OF LEAD.

Sugar of Lead, $Pb(C_2H_3O_2)_2$. The main use of this salt is as a source of acetic acid, in preparing acetates of alumina and other oxides. It occurs as well-defined crystals, soluble in about 3½ times their weight of water, whether hot or cold. The solution reddens litmus; on exposure to the air a slight precipitation of carbonate of lead forms, caused by the carbonic acid of the atmosphere.

Nitrate of Lead, $Pb(NO_3)_2$. This salt is used for dyeing, producing yellows and oranges. It is a heavy, white, crystalline salt, soluble in water: 100 parts at 25° C. dissolve 60½ parts of the salt nitrate of lead.

SALTS OF ANTIMONY.

Tartar Emetic, $(K(SbO)C_4H_4O_6)_2H_2O$, is employed for treating cloth that has been printed with colours mordanted with tannic acid. It is a crystalline salt, soluble in water; it is a double tartrate of potash and antimony, and contains when pure about 36 per cent. of antimonious oxide. When bought in the crystalline state it is generally pure, but when in powder may contain a large amount of water and of mineral impurities.

COMPOUNDS OF ARSENIC.

White Arsenic, Arsenic trioxide. or Arsenious oxide, or Arsenious acid (As_2O_3).—This oxide is used for fastening aniline colours fixed with alumina. It is met with in commerce as a fine white powder; it is only slightly soluble in water, a little more soluble in hydrochloric acid, but it dissolves in the alkalies, forming *arsenites*, commonly termed *arseniates*. Thus, white arsenic dissolves in hot caustic soda to form arsenite of soda. The arsenites of the other metals are insoluble in water, but dissolve in acids; a neutral solution of arsenite of soda gives with copper sulphate, a green precipitate, with ferric chloride a reddish-brown precipitate, and with silver nitrate a yellow precipitate. Arsenious oxide dissolves also in a solution of borax and in glycerine. For use in mixing aniline colours the latter solvent—glycerine—is mostly used, the arsenic and glycerine being boiled until solution occurs; good commercial glycerine dissolves 6 to 7 lb. of arsenic per gallon, but it is desirable to have an excess of glycerine, as, if saturated, a portion of the arsenic is thrown down on standing or on addition of water.

Nitric acid, bleaching powder, and other oxidising agents convert arsenious acid into arsenic acid, which compound we come to later on.

Mention may here be made of the powerfully poisonous properties of arsenious oxide, and great care should be observed in using it in the colour-shop: a dose of two to four grains is sufficient to prove fatal in most cases, unless at once ejected from the stomach or rendered harmless by precipitation as an insoluble compound. Many antidotes have been proposed for the poison, sulphuretted hydrogen and freshly precipitated ferrous hydroxide or hydrate being the most efficient.

Arsenic Acid (H_3AsO_4), in the form of a liquid of specific gravity 1·8, is occasionally used in colour mixing—especially in acid resists. It is also used for making arsenate of alumina by dissolving in it hydrate of alumina. Arsenic acid is obtained by the oxidation of arsenious acid with nitric acid, and hence the commercial article is apt to contain small quantities of free nitric acid, which, of course, is an objectionable impurity. The strong aqueous solution acts as a cautery on the skin. The percentage of acid in solutions of different specific gravities, according to the investigations of Schiff, is shown in the following table:—

Specific Gravity.	*Percentage of H_3AsO_4.*
1·7346	[illegible]
1·3973	45·0
1·2350	30·0
1·1606	22·5
1·1052	15·0
1·0495	7·5

The *arsenates* of alkali are largely used in Turkey-red dyeing. (See paragraph on Bin-Arseniate of Soda.) Arsenic acid is tribasic, and forms three series of salts.

SALTS OF COPPER.

Sulphate of Copper, Blue Stone or Blue Copperas ($CuSO_4 + 5H_2O$).—The use of this salt in calico printing is very limited; it is used for making sulphide and acetate of copper, and in catechu colours. It occurs in fine blue crystals, soluble in water.

Acetate and Nitrate of Copper are used very sparingly; their only application of importance is in catechu colours which are thickened with gum; the copper salts are supposed to destroy and counteract the injurious action of the gum. It must be remembered, too, that copper yields with alizarine a brown, so that in printing catechu and dyeing alizarine a better shade is produced by the addition of copper salts.

Sulphide of Copper is used for oxidising aniline blacks. It is a black insoluble substance, obtained either by precipitating a soluble salt of copper with sulphide of soda, or by the direct action of metallic copper and sulphur. It is generally made in the colour-shop by the former method.

THE CHEMISTRY OF COLOURING-MATTERS.

The number of substances available for colouring fabrics is very large; and their composition and properties are of widely different characters. We shall omit mention, however, of those colouring-matters which, owing either to their cost or their instability, are now displaced by better substitutes. The introduction of the aniline and other artificial colours has occasioned a great change in the stock of the dyes used by the calico printer; many expensive and loose colours which were in extensive use a few years ago are now completely replaced by cheaper and faster colours. The colouring-matters used in modern calico printing may conveniently be divided into four heads: (1) mineral, (2) vegetable, (3) artificial, and (4) miscellaneous colouring-matters.

(1) MINERAL COLOURING-MATTERS.

These are coloured compounds of mineral origin, insoluble in water, and are fixed to the cloth either ready-formed in the state of pigments, by mechanical means; or they are deposited in the fibres of the cloth by chemical reactions.

Whites.

White is seldom printed-on as a colour. Bleached calico is pure white, and it is left unprinted upon where white parts are required. In a few instances, however, white pigment is employed.

French white is the best white pigment. It is the oxide of zinc, ZnO, and is of pure white. It is also used for mechanical "resists"—being printed-on with gum, dried, and some other colour padded all over the cloth.

Reds.

The most important red is vermilion or sulphide of mercury, which is a brilliant scarlet obtained either by fusing together 14 parts of sulphur and 108 parts of mercury in iron crucibles and then in the sand-bath; or in the wet way by precipitating an ammoniacal solution of corrosive sublimate by ammonium sulphide; the beautiful red precipitate thus obtained is thrown on a filter, washed and dried. This pigment is printed on the cloth mixed with a thickening consisting of a mixture of a solution of albumen and gum dragon; the fabric is then *steamed*, by which the albumen is coagulated or rendered insoluble and the pigment firmly fixed on the cloth. This gives a splendid scarlet colour, fast against almost all reagents and against light, soap and friction. This colour would be much more extensively employed but for its high price. It is now used only for discharge red on indigo blue.

Red lead, or minium, an oxide of lead, was formerly used; also realgar or bisulphide of arsenic, antimonial vermilion or tersulphide of antimony; but all are now superseded.

Blue and Violet Pigments.

The chief pigment blue colour is ultramarine, the most valuable of all pigment colours. Formerly—in the beginning of the present century—this magnificent colour was only known as a rare and expensive mineral, mostly used as an artist's pigment. It exists in nature in the rare mineral *lapis lazuli*; and this was the only source of the colour.

THE GEOMETRICAL DRAUGHTSMAN.

His Work in the Construction of the Figures and Problems of Plane Geometry, Useful in Technical Work.

CHAPTER XI.

In the last paragraph of preceding chapter we referred to the fact that the expression "mean and extreme proportional" was incorrect, and promised to make its meaning clear to beginners. It is sufficient for this to know that the word proportional was formerly used for "in connection with"; thus the idea of connection shows at once that there is a certain proportion to be considered. Now, to make a proportion with a quantity, and the parts of this quantity divided in two, which makes in all three quantities, there must be one which is used twice, which is the mean proportional between the two others; and it is quite evident that it can only be the one which from its size is intermediate between the two others.

Thus, to divide a straight line in mean and extreme proportional evidently means to divide this straight line in such a way that we may make a proportion with the two parts and the whole straight line. If A B (fig. 59) is the straight line, A D the largest segment, and B D the smallest, we shall have the proportion $\frac{AB}{AD} = \frac{AD}{BD}$. The words mean and extreme signify that one of the parts serves to form the middle term of the proportion that is to be established, and that the other part of it is the extreme term. To sum up, the term to divide a straight line in mean and extreme proportional should be considered as an abbreviation corrupted from the expression to divide a straight line into two parts which serve the one as mean, the other as extreme, to a proportion (understanding that it is the entire straight line which forms the other extreme). Let us now glance at the constructions as illustrated in fig. 59. Let A B be the line to divide in mean and extreme proportional. At the end B erect the perpendicular B O, and from the point O as a centre, with O B as radius, describe a circle: O B is equal to $\frac{AB}{2}$ or half A B. Join A O: this line cuts in point C the circle O B. From point A as a centre, with a radius A C, describe an arc which meets or cuts the line A B in the point D: this point cuts the line A B in the points required,—namely, in mean and extreme proportional. This is demonstrated thus. Extend or produce the line A C′ till it cuts the circle O B in the point C; then we have

$$\frac{AC'}{AB} = \frac{AB}{AC'}, \text{ or } \frac{AD + AB}{AB} = \frac{AB}{AD},$$

because by the construction already given we have C C′ = A B and A C = A D. From this it comes that $\frac{AD}{AB} = \frac{AB - AD}{AD}$, and as A B — A D = B D, it becomes finally $\frac{AD}{AB} = \frac{BD}{AD}$, or which is equivalent to—

$$\frac{AB}{AD} = \frac{AD}{BD}.$$

Geometrical Surfaces—Figures.

The young geometrical draughtsman should distinguish between the two great classes of geometrical objects: first, those of surfaces or superficies; and second, those of solids. The distinction between the two may be popularly indicated by saying that geometrical surfaces or superficies are "figures" or "outlines"; geometrical solids are "forms" or "bodies"—the latter term being the most distinctive, and that which is generally employed in technical language. A surface or "figure" or "outline" has always, and only, two dimensions—namely, its length, and its breadth or width; —it has no thickness or depth. A "solid" or "form" or "body," in addition to length and breadth or width, has thickness or depth; these three dimensions must therefore always form the factors in estimating the solidity of the body; just as the length and breadth must always be taken together in estimating the extent or surface or superficies of a figure or outline. The rules for applying those dimensions in connection with the various geometrical figures and forms will be found in the series of papers under the head of "The Practical Technical Measurer," should space be at our command for it. It is with the delineation or construction of the geometrical surfaces, figures, or outlines with which in the present series we have to concern ourselves. What may be called the fundamental problems on construction—namely, those connected with the *lines* which go to form all figures —have been already considered in foregoing chapters. We now proceed to the consideration of construction connected with polygons.

Different Kinds of Figures on Surfaces, Planes, Triangles, Polygons.

There are three kinds of surfaces: the flat, the concave, and the convex. A surface is flat when we can apply a straight-edge or ruler to it in any direction. A table, a picture, or drawing-board are flat surfaces. A concave surface is that of a hollow object, as the interior of a basin. A convex surface is the external or outer surface of a hollow or concave, as the outside of a vase, of a column, or of a ball. When we consider a flat surface, we naturally think of its limits; the surface defined by that limit takes the name of a "plane" or a "plane surface," or "figure," or an "outline figure." By these terms we understand an object formed by lines, of which there *must* always be more than two. The lowest number of lines required to form a figure is three. Figures thus formed of three ines are called triangles, the varieties of which are distinguished by names founded or based upon the relation, or angles (see preceding chapter), which the lines have to one another. The term "polygon," meaning literally a many-sided figure, may apply to triangles or plane surfaces, or figures formed by three lines only—or to triangles; and some geometricians include triangles in the list of polygons. Others, and we think more accurately, exclude triangles—which, as we have seen, are figures having the minimum or lowest number of sides; and begin the class of "polygons" with the figures having four sides—as squares, rectangles, rhomboids, etc. Others exclude even these, and commence the polygons with plane surfaces or figures having five lines. This is probably the best arrangement, as the term many-sided figure can more easily be considered correct when applied to a figure having more sides than three or even four, than when it is applied to figures having only those number of lines.

Polygons are either "rectilineal," right or straight lined; "curvilineal," or curved or bent lines; or what may be called "mixtilineal," or combined figures partly made up of straight and partly of curved lines, according as they are limited by straight lines or curved lines, or by straight and curved lines. In this series we shall only take up the consideration of the rectilineal polygons.

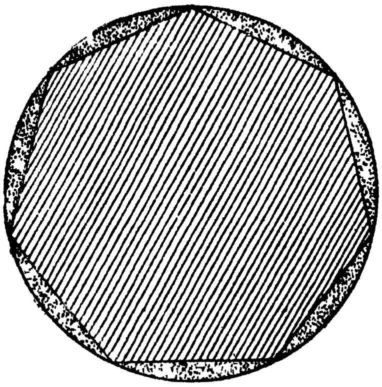


Fig. 60.

Terms connected with Polygons—Definition.

The polygonal figures of the other classes will be considered in one or other of the chapters of the series of papers entitled "The Architectural and Engineering Draughtsman." The whole of the lines which form a polygon are called the "perimeter" of the figure. Each line is called a "side-rule.". A polygon is equilateral when all the sides are equal; a polygon is equiangular when all the angles are equal. A polygon which is at the same time equiangular and equilateral—that is to say, which has all its angles and all its sides equal—is termed a "regular polygon." An "irregular polygon" is one the angles or the sides of which are not equal. An "inscribed polygon" is one all the angles of which are included within another figure, as a circle. Every regular polygon may be inscribed within a circle, as in fig. 60. We understand by a "circumscribed polygon" one all the sides of which are tangential to a circle—that is, the circle is inscribed in the polygon, as in fig. 61, or the polygon is described about the circle. The sides of a circumscribed polygon can always be parallel to those of an inscribed polygon of the same number of sides. There is an endless variety of polygons, according to the number of their sides. The triangle is the polygon of three sides; the quadrilateral, that of four; the pentagon, that of five; the hexagon, that of six; the heptagon, that of seven; the octagon, that of eight; the nonagon, that of nine; the decagon, that of ten; the dodecagon, that of twelve; and so on.

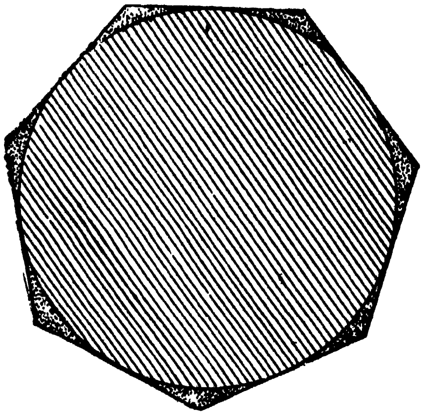


Fig. 61.

Figures of Three Sides—Triangles—Terms, Definitions, and Points connected with the Figure or Surface.

We have already stated that some authorities begin their polygons with five-sided figures. We deem it best for the purposes of reference and consecutive classification to include triangles within the list of polygons. As we have said, the triangle is the simplest of the polygons; its name is sufficient to show that it is composed of three angles, *a*, *b*, *c*, formed by three sides, as *a b*, *b c*, *c a*, fig. 62. In a triangle, any side whatever is always smaller than the sum of the two others.

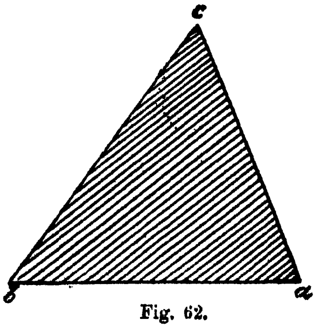


Fig. 62.

THE JOINER.

THE GENERAL PRINCIPLES AND THE DETAILS OF HIS WORK.

CHAPTER XII.

In the French window described at end of last chapter (p. 133), the weather board is also weathered at upper surface, giving an inclined surface for the rain to slide off, the throating under preventing this from creeping in behind the board, as it cannot cross the groove. This weather board is secured in two halves to the bottom bars and sides of the sheets. To cover internally the vertical joint when the window is closed, the moulded bar *e*, fig. 1, Plate CXVI., is secured to one of the vertical bars or stylès, as *a*; the panes of glass are at *f f*, and *g g* is the window sill in the interior of the room. The parts below this are similar to the arrangement in fig. 1, Plate LII. Still further to secure a water-tight joint at bottom of casement near the sill, the bottom bar at *i*, in diagram B, fig. 3, Plate LII., lies, when the window is closed, against the cross-bar *j*. The bottom bar of sheets may be made still deeper, making the joint still the longer up which the rain has to be blown before it can enter the room: this is shown in diagram A, fig. 3, Plate LII., at *h*; *c*, *d*, *e*, *f* and *g* are parts corresponding to those in upper and lower diagram in fig. 1, Plate CXVI. In place of the square rebate *c*, as in upper diagram in fig. 1, Plate CXVI., the meeting vertical joint of sheets is constructed, as in fig. 4, diagram A, Plate LII., at *a b*, covering pieces being outside and inside to conceal the joint and make it externally water-tight. Fig. 4, Plate LII., diagram B, is part cross section and part elevation, of inner edge of vertical bar, as at *h* in fig. 1, Plate CXVI. If the sheet be divided either horizontally or vertically by an astragal, the section of this will be as in fig. 5, Plate CLXXX., at B, dimensions and general outline or elevation being as in same figure, diagram C.

Venetian Windows

are what are called "three-light" or three-sheet windows, but of which the central light, as *a a' a*, fig. 6, Plate CLXXX., is wider than the two side lights, *b b' b'*, *c c' c'*; the lights are divided by solid piers, *e e*, *e' e'*, in stone, or of flat mullions in wood. In the plan in lower diagram *d' d'* is the wall broken by the three voids. Fig. 3, Plate CXVI., gives in elevation and section part of a mullion or pier, as *e e*, *e' e'*, in fig. 6, Plate CLXXX., showing mode of ornamenting them when of wood. Fig. 5, Plate CXVI., shows the method of hanging the sashes, the parts being the same as in this portion of an ordinary sash window: see fig. 2, Plate LII.

Bay Windows

are, like the "Venetian" windows, "three-light"; but in place of having all the three in the same panel or running in the same flat surface of the wall, as in fig. 6, Plate CLXXX., have the side lights, as *c c*, *d d*, fig. 7, Plate CLXXX., oblique, or at an angle to the central light *a a*, which runs in the same plane as the walls *e e*. The central light *a a* is divided by piers, *b*, *b*, from the side lights, which are shown in the plan forming the lower diagram of fig. 7, Plate CLXXX. The mode of fixing the sash-weight boxes, or of hanging the lights from a bay window, is shown in fig. 2, Plate CXVI.; the parts indicated by accented letters forming the part for the central light, corresponding to *a a*,—those not accented the points for the side lights, corresponding to *c c*, fig. 7, Plate CLXXX. (See fig. 4, Plate CXVI.)

Bow and "V" Windows.

Bow windows are often considered the same as bay windows, but the distinction between them, which is very marked, is easily remembered. In a "bay" window there are three lights, and the plan forms part either of a hexagon or an octagon, as shown in the plan in fig. 7, Plate CLX. In a "bow" window the plan is either semicircular, or part or a segment of a circle less than a semicircle. The form of "V" windows is, as their name indicates, made up of two lights, as *a a*, *a' a'*, fig. 1, Plate CXCVII., placed at an acute angle, and meeting in a sharp end or arris at *c*, *c c* the wall from which the angular walls spring. In the figure the sashes or lights are fixed, not hung as in the windows in fig. 2, Plate LII., and figs. 2 and 5, Plate CXVI.

Window Shutters.

The shutters most generally employed are of the class known as "folding," so called from the boards being hinged together at their edges, and folding in upon one another so as to occupy a much less space than when they are opened out and extended. When so folded up they are pushed back into a recess made in the wall, or provided for by wooden constructions or cases where the thickness of the wall does not admit of the depth of cases or recesses necessary to hold the shutters. These recesses, however formed, are called "shutter boxes," and when formed in recesses in the thickness of the walls they are lined with wood. The simplest form of shutter and shutter-boxing is shown in fig. 3, Plate LXXXIII.: *a a b c* the wall in which the recess is made; *h* the line of window to be covered by the shutter *f g h i*. The back part or board, as *e b*, is called the "back lining," *d e*, *c b*, the "side linings." Shutters are either plain or panelled, the latter being of course employed in the better class of buildings. There are two shutters or "flaps," as the leaves are technically termed, in the plan in fig. 3, Plate LXXXIII.—the "front flap," as *g g h*, only panelled, *f f* being the "styles" into which the panels are fitted. The "back flap" is at *i i*, and is plain. When the shutters are in place in the box, the front or outside face to the room shows panelled. It may be a square panel flush or flat at back, as shown, or it may show panelled on both sides. Fig. 2, Plate LXXXIII., is part elevation of shutter front panelled. Fig. 3, Plate CXCVII., shows shutter boxing with three flap shutters. In this case the centre flap is called the "second flap," *jj ll m* the front flap, and *fgf* the "back flap." The "back lining" is at *b b*, *c* being ground into the two pieces or styles *b b*. This plan is for a Venetian window. The diagram to the left in fig. 4, Plate CXCVII., shows shutters and boxing for a bay window. Where the boxing is not made in a recess in the wall, but projects from the wall, the side of the box is ornamented with an architrave moulding, as at *i i* in diagram to the right in fig. 4, Plate CXCVII. Where no shutters are used, the diagram in fig. 2, same plate, shows how the meeting angles of walls from a bay window may be inclosed by a diagonal piece moulded in face.

THE BRICKLAYER OR BRICKSETTER.

THE PRINCIPLES AND PRACTICAL DETAILS OF HIS WORK.

CHAPTER XI.

AT end of last chapter we began a description of the various kinds of walls, ending with the first kind. The *second* kind are walls with "returns"—that is, another wall running at right angles to the front wall. The return may be only at one end, as *c* the wall *b* (fig. 21); or with two returns, one at each end, as at *e e*. *Third*, a straight wall, as at *a a*, or one with return, as *c*, or two as at *e e*, having another wall, *g*, projecting at right angles from any part of the wall *f f*. The wall *g* may be of equal, greater, or less thickness than the main wall *f*. *Fourth*, walls with recesses, either with square or arched heads, made at some point, as *i* in the wall *h h*. *Fifth*, a straight running wall, as a garden wall, terminated with square piers or columns at one or both ends, as *k k* in the wall *j j*. All these walls are open walls, inclosing spaces, as yards, or the interior of a house. To these classes has to be added a *sixth*—namely, walls facing earthwork behind, and known as "retaining walls." Walls may be made flush or even on their surfaces—that is, of equal thickness throughout their whole length; but when they are very high, and consequently very thick at the bottom, "offsets" are made at certain heights, as at *a b c*, fig. 22, gradually reducing the thickness as the wall approaches its upper termination. This is illustrated in fig. 22, *d d* being the footings, *e e* ground level or

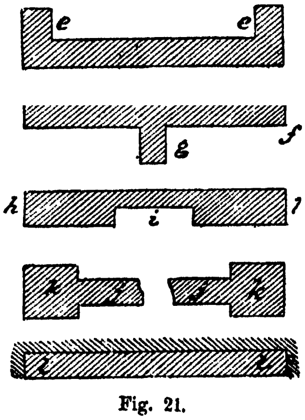


Fig. 21.

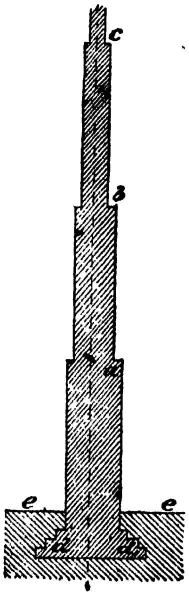


Fig 22.

High Walls decrease in Thickness as they go up.

Where the wall of a house is of great height, the thickness of the wall gradually decreases, the inclosing walls of the first floor being thinner than those of the ground floor below; the walls of the second floor being thinner than those of the first, and so on. The thicknesses are reduced by offsets, precisely as shown in fig. 22, at *a b c*; with this difference, however—that the offsets are all confined to the inner side of the wall of house. The reason for this is obvious; it being essential that the surface of wall outside, or to the street, should be uniform or all on one plane.

Varieties of Straight or Plain-running Walls.—A Nine-inch or Brick-thick Wall in "Flemish Bond."

The two first courses of a nine-inch wall in "Flemish bond," with square terminations, as at *a a*, in fig. 21, are illustrated in fig. 23. In naming the numbers or the individual bricks of which each course is made up, we begin at the left-hand end of the wall. The other, or right-hand termination, is precisely the same as the left-hand, and is shown in all the diagrams.

First course, A, fig. 23.

Two stretchers *a a*, a header *b*; two stretchers *c c*, a header *d*; and so on alternately along the whole length.

Second course, B, fig. 23.

A header *e*, a half-closer *f*, two stretchers *g h*, a header *i*, two stretchers *j k*, a header, and so on alternately.

The front elevation is shown in C, fig. 23, the "end elevation," in fig. 24, being taken on the line 1 2, in B, fig. 23.

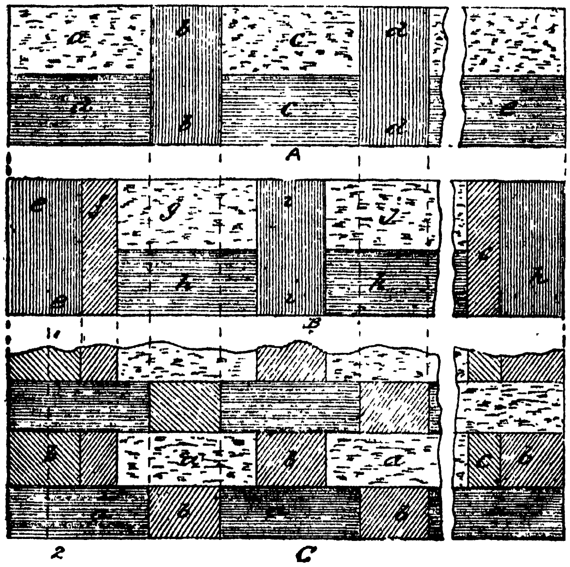


Fig. 23.

The two courses of a nine-inch wall with "return" at end, as *c* in fig. 21, in Flemish bond:—

First course, fig. 25.

Front wall 1 2, a header *a*, two stretchers *b c*, a header *d*, two stretchers *e f*, and so on alternately. Return or end wall 3 4, a stretcher *g*, a half-closer *h*, two stretchers *i j*, a header *g k*, two stretchers, and so on alternately.

Second course, fig. 25.

Front wall 1 2, a header *l*, a half-closer *m*, a header *n*, two stretchers *o p*, a header *q*, two stretchers *r s*, and so on alternately. Return wall 1 3, a header *t*, two stretchers *u v*, a header *w*, two stretchers, and so on alternately.

The two courses of a nine-inch wall, Flemish bond, with "return" at the centre, or another wall at right angles, as at *g* in wall *f*, fig. 21 (*ante*), illustrated in figs. 26 and 27 :—

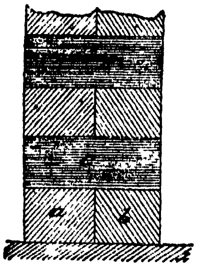


Fig. 24.

First course, fig. 26.

Wall 1 2, right and left of 3 4, a header *a a*, two stretchers *b c*, a header *d*, etc., etc. Wall 3 4, a stretcher *e*, a half-closer *f*, two stretchers *g h*, a header *i*, two stretchers *j k*, etc.

Second course, fig. 27.

Wall 1 2, two stretchers *a b*, and header *c*, alternately, the ends finished as in fig. 25. Wall 3 4, a header *d*, two stretchers *e f*, a header *g*, etc.

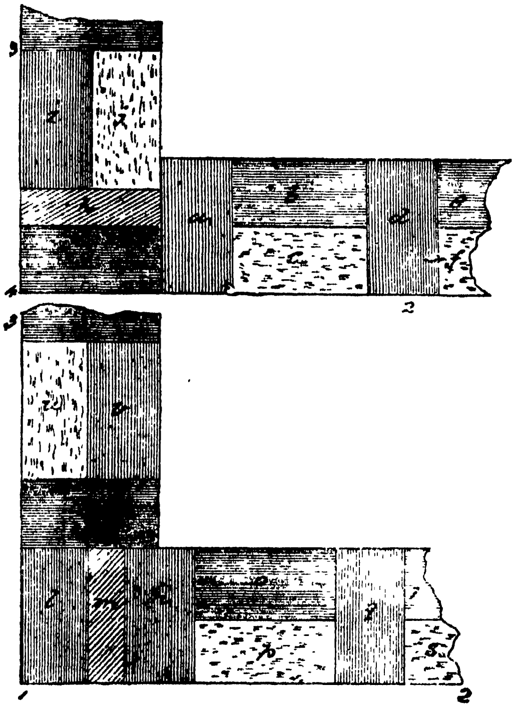


Fig. 25.

A Fourteen-Inch or Brick-and-Half Wall in Flemish Bond.

First course in A, fig. 28.

A header *a* and a bat or half-brick at *b*. Two closers—a half-brick *c*, and a quarter ditto at *d*; a stretcher *e*, and two headers *f* and *g*; a half-brick

Second course in B, fig. 28.

Three stretchers *a b c*, a header *d*, two stretchers *e* and *f*, a header *g*, and two stretchers *h* and *i*, and so on alternately; these bricks are at end or bat *h*, and a header *i*; a stretcher *j*, and two headers *k* and *l*; a bat *m* and a header, then a stretcher *j*, two headers *k* and *l*, and so on alternately throughout the course.

and front; at back a stretcher *j*, a bat or half-brick *k*, a second ditto *l*, then a stretcher *m*, and so on.

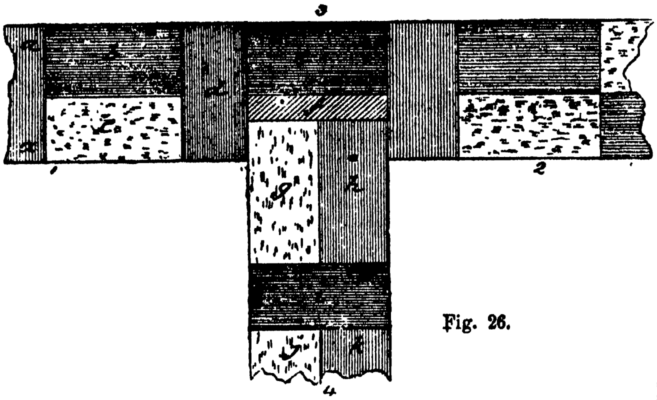


Fig. 26.

In fig. 29 we give part front elevation of this wall, in which *a*, *d*, *e*, *h*, and *j* correspond to the parts similarly lettered in plan diagram A, fig. 28. These make up the first course in elevation; the second is made up of bricks *c d f*, corresponding to those similarly lettered in diagram B, fig. 28. In fig. 30 we give end vertical view, looking at fig. 29 in direction of the arrow 1; letters in this correspond to letters in *a* and *b*, fig. 28.

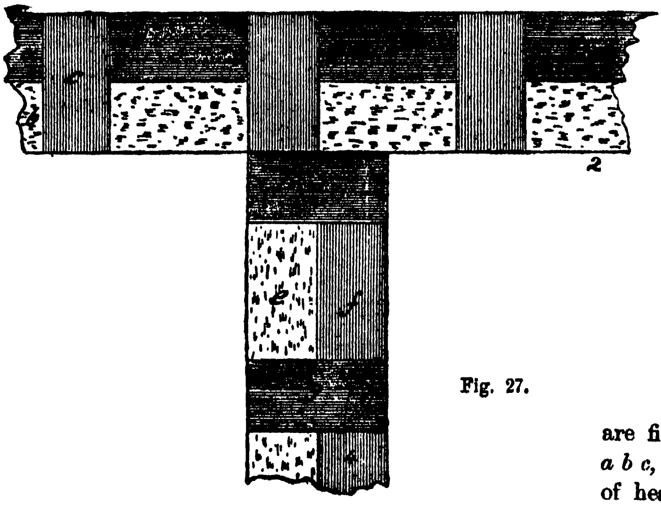


Fig. 27.

A Nine-Inch or Brick-Thick Wall in "Old English Bond."

First course, A. fig. 31, is made up of a series of stretchers *a a* in two rows, placed side by side and end to end along the length of projected wall.

Second course, B, fig. 31, is made up of a series of headers *b b b*, placed side by side in single row.

Starting from one end with the two rows coincident to form the face of each, as the breadth of a brick is just half its length; if the second course, as B, was placed on the first course in A, the joints as 1 2 of the second course would coincide with the joint as 3 4 of the first

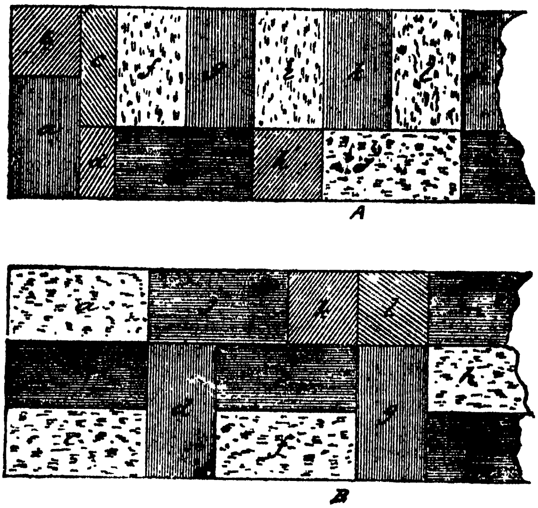


Fig. 28.

course, so that no vertical bond would be obtained. To get rid of this grave objection, a "closer," as *c* in diagram B, is inserted in second course, which breaks the joints of all the courses, as shown in fig. 32, which is front elevation, fig. 33 being an end view.

A Fourteen-Inch or Brick-and-Half Wall in Old English Bond.

First course A in fig. 34. Starting from the right, are first three stretchers *a b c*, and in front a row of headers *d d d*, and at back a row of stretchers *d d*.

Second course B in fig. 34. Starting also from the right, we have a header *a* and a bat or half-brick *b*, a half-brick closer *c*, and a quarter-brick ditto *d*; at front a row of stretchers *e e*, and at back of headers *f f*.

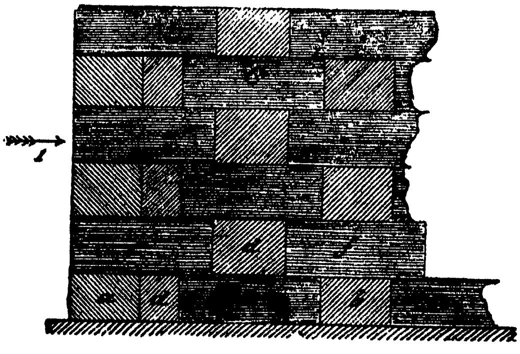


Fig. 29.

In fig. 35 we give front, and in fig. 36 end elevation; the letters correspond to correspondingly lettered bricks in fig. 34.

THE WORKMAN AS A TECHNICAL STUDENT.

How to Study, and What to Study.

CHAPTER VIII.

At the conclusion of the last chapter we pointed out the reasons why practical men frequently have a reluctance to adopt new inventions and processes, and why they feel it safe to be content with the old plant. We thus see that many things conspire to urge the practical man to be at least very careful in adopting a new method, when the old one has, to say the least, been moderately successful. And although such views may in great measure be upheld by pure prejudice, still there are not a few considerations which are not prejudices, but really the outcome of a prudent business policy. Nevertheless it is true that, as a rule, however few they may be, still practical men who have been long in any branch of industrial work have some prejudices which are the more difficult to be got rid of inasmuch as they are founded upon what are mere conjectures or assumptions, not facts truly such. Indeed, it is not always easy to prove them to be conjectures merely; for some processes are so obscure, and the circumstances under which they are carried out are such, that a tracing up of all the steps of the process is absolutely impossible. Still those conjectures stand as good and as potent in their way as prejudices, and indeed give rise to opinions which are purely so.

Business Relations between the Theorist and the Practical Man.

But the theorist, who has no pecuniary interest in upholding any established system of working, if he is influenced at all by money considerations—and many theorists are singularly free from such—has obviously every inducement to get his system established, as its being carried out is the only way in which he can be benefited pecuniarily. But apart from all such business considerations, the theorist comes to the study of the subject wholly free from all notions and prejudices which can only have existed with those who have long been engaged in carrying out an established system. What that system is the theorist sees as it is, not as the practical worker believes it to be, or so that it may coincide with some notions or pet views of his own he wishes it to be. In nine cases out of ten the theorist is urged to investigate the subject purely from a love of science—and possibly from one of those unaccountable likings for the particular branch; or urged by something which it is difficult for him to divine. He may have not the slightest wish to make money by his investigation; yet his very first discovery may be that which is to bring about a system by which the capability of the trade to give profits may be enormously increased. It not seldom has happened that the theorist has been the most surprised of all at the pecuniary value of his discovery. In making this, in being led up to it by his close and scientific investigation, the theorist is guided only by one desire, has only one object to serve; being free, moreover, from all notions resulting from long-continued experience with the old system, he can devote his full energies to his work of investigation perfectly untrammelled by preconceived notions. If a truly scientific man—for there is a pseudo or false as well as there is a true science—he does not go to his investigation with a theory to which he makes or tries to make all the facts of actual work square: he takes facts and facts only to prove his theory; or rather, the theory is finally formed simply because he takes facts and reads the lessons which they teach. But the theorist has not merely to contend with the prejudices of the practical man, and to meet all his business objections; he has to contend "with those of his own house." Scientific men considered purely as such are, no more than any other body of men, free from the pangs of professional jealousy, untainted with the poison of personal dislike. So influenced, indeed, either by the one or the other or by both, but chiefly, one is glad to say, by the former of them, are scientific men, that their disputes are notorious as being characterised by a warmth at least of expression if not of feeling; through which not merely are uncomplimentary opinions as to ability freely bandied about, but sometimes statements made which reflect severely on the *morale* of their opponents. It need not, therefore, be matter of surprise for the reader to learn that there is scarcely a new scientific theory broached or opinion given, but what several, often indeed many, scientific men rush into print or speech with theories and opinions wholly counter to it. And of the two it is perhaps true to say that the difficulties which a new system has to encounter from men of science before it is accepted and established are greater and more difficult to be overcome than those which emanate from the practical men. And the reader will here see that the prejudices and trade notions of the practical men—antagonistic to the new system—are likely to be greatly deepened in intensity by the fact that the system is denounced as erroneous by men of science. The practical man is therefore from this very circumstance scarcely to blame for refusing to adopt a system which he finds so condemned by other men of science. And if two schools be formed, one for, the other against the new system, he may find them so equally balanced as regards position and attainments, that he is little to be censured for hesitating to decide between them, and for making up his mind to do what he thinks is at least the prudent thing to do—that is, to do nothing at all in the matter, but allow the new system to be to him as if it had never existed.

The Relation between Practice and Theory as closely affecting the Question of Technical Education.—The "What" and the "How" to Study.

From what has been now said as to the relative positions of theory and practice, the reader will perceive the important bearing which the point has upon his prospects in life, and how closely it affects the question of study as one of the elements which go to insure success in it. He will perceive also the necessity that exists, if that success in life be desired, of giving due heed to the claims of theory as well as of practice—for it is only sound practice which is guided and controlled by sound theory. This union of the two inciting causes of action in life affects *study* as well as workshop practice. This from the nature of things must be, although it is true that the opinion that theory and practice are antagonistic is held forcibly, not merely by those being taught, but by some of those who teach.

In devising a system of education fitted for technical pursuits, much of course depends upon the branch of business which the student intends to follow up, or is at present connected with. Thus it is obvious that those engaged in one or other of the branches of what is generally classed as manufacturing chemistry will require to be made acquainted with certain departments of science specially applicable to this department—branches which, studied carefully, would not, however valuable, generally be of direct value to those engaged in one or other of the constructive arts, as that of the carpenter or the machinist. Still there is what is applicable to all callings, a general course of study which forms the basis of all special studies. And although special subjects are required for special callings, there is one system applicable to all alike—namely, the method of studying: that is, while the "what" to study varies with varying circumstances, the "how" to study is and remains the same for all circumstances. And on this important "how" to study we have now to make sundry remarks to which we crave the close attention of the reader.

In devising a system of education fitted for technical students, the difficulty connected with the opinion but too generally held as to the claims of theory and of practice, and to which, with its practical effects in technical trades, we have already drawn special attention, comes up for consideration. And some, it must be confessed, make a great difficulty in drawing or attempting to draw a clear line of distinction between theory and the design and processes which depend upon theory. But in point of fact the circumstances of actual life do in effect draw this line, marking off the labours of the class or study as distinct from those of the workshop, the factory, or the business establishment. Nevertheless the education, briefly so called, of the technical student, as say a carpenter or engineer, is only completed when the union between those two divisions is perfected. And this will be so when on the one hand the acquirements of the class or the study can be brought to bear upon the practice of the workshop in a manner so ready as to be almost intuitively performed, and in a way so certain that the most accurate results may be depended upon; while on the other the practical knowledge of the workshop comes in to help the realisation of the designer, so that his work shall be executed in a way at once sound, accurate, and economical. This last term is but a short way of expressing the fact that the maximum amount of good work is secured by the least expenditure of time and materials. On which important point in workshop economics we shall in a succeeding paper have somewhat to say. The two divisions, then, are not, as some seem to think, different, separate in aim, and to be separately followed out, but in the most accurate sense of the term constitute but one, and that is comprised in the phrase "practical education," as for example of the engineer or of the carpenter. The details of each act and react upon each other; and each in turn and in the most easy and natural of ways takes the place of master and of servant—offering in this relationship none of those ever-jarring and antagonistic influences so observable in other unions. We have only alluded to them here as two, from the circumstances of daily life, which apparently so classify them, as well as for the purposes of easy reference; it is, however, difficult to overestimate the evils arising from the assumption made by some that they are in reality two different things, with differing aims, objects, and methods to be pursued. We have said that this erroneous view is held by some: it would be more correct to say that it is maintained by the great majority of those practically engaged in carrying on the work of technical establishments and industrial workshops. But the evil done to working men by this belief is unfortunately perpetuated and intensified by the fact that the same opinion is held by so large a number, if they do not indeed constitute the larger proportion, of those who have the conduct of the education of our youth. It is indeed from this that technical education has hitherto formed no part of our national system of general education. This has greatly retarded its introduction, and is one of the reasons why so many of the efforts which have been made to introduce it into everyday educational life have been such miserable failures. It is, however, most gratifying to know that juster views are now held by those immediately concerned in the carrying out of our national system of general education. It is scarcely necessary to say that our strictures on this point refer specially to the general system or systems of education—in which of late years, at all events, there is supposed to be some relation between the subjects taught and the after life or technical pursuits of the pupils. In the purely technical schools or colleges now being rapidly multiplied throughout the country, the due relationship between theory and practice, or rather their inseparable connection, is fully recognised. And this is likely to be the case, when we consider the able men who have taken part in their organisation. It is doubtful, however, whether some who may succeed them may not lose sight of this, and give an undue preference to theory. If the true relationship between scientific theory and practical work which we have indicated be once well understood and acted upon, we shall have little fear that it will not be properly carried out. In this we place our reliance upon the practical, common-sense way in which work is done by us as a people, pre-eminently workers as we are, when once we apprehend the nature and appreciate at least in some fair degree the value of the work required to be done. We look forward, therefore, with hope to the coming of the time when the true character of technical, or as we may here call it, practical education, shall be comprehended by our teachers as a body. The pernicious, because false notions, held now by so many as to the antagonism—that is, the assumed antagonism—between theory or science and practice will vanish; and along with this, other fallacies which are but the offspring of this, the greatest fallacy of all. Not science *and* practice, but science *with* practice, and practice with science, always conjoined, working to the common end, and with aims in common: in other words, "scientific practice."

Difficulty in uniting Theory with Practice in a System of Technical Education.—The Relation of this to Teachers.

On the other hand, it is only right to concede that those teachers are in a difficulty who, agreeing with the views entertained by the most advanced and practical men of the day—that if we, as a working people, are to maintain our supremacy as the producers of the world, we must henceforth make technical not a subsidiary but a leading part of national education—nevertheless, in their system, lean but too much to theoretical exposition. For while it is incontestable that the union of practice with theory—or, in other words, as we have put it, scientific practice—must be maintained and carried out, the details of teaching which this, as a matter of course, dictates and compels, are not very easily attained. In point of fact, this is precisely the difficulty which faces teachers in general. For seeing that technical work in the main certainly involves, as an integral part of it, the doing, the making, of something — in other words, the supplementing of the designs of the mind by the labours of the hand—this making involves appliances, and those again places or apartments specially designed for the reception and working of them. Teachers, therefore, naturally inquire how they are to obtain those facilities, and they very reasonably point out that if their circumstances debar them from following up one branch, they are compelled to devote their attention to what is within their reach—namely, the purely theoretical or oral instruction. Hence it is that, in view of this difficulty, purely technical schools and colleges are being erected and organised, in which every convenience and appliance is supplied by which the union of science with practice is secured in a thoroughly efficient manner.

Relation of Working Men, considered as Pupils, to an Extended System of Technical Education.

But while those institutions are well calculated to give a sound technical knowledge to those who attend them, it must not be overlooked—although it is so by but too many—that they will only be availed of by a comparatively limited number of pupils. And the misfortune of the matter, as it appears to many, is that those who are likely, we might say almost certain, to attend will not be of the class it is so desirable to influence by sound technical education. And that this view is likely to be accurate seems only reasonable to believe, seeing that it is held by those who have a thoroughly practical, because mainly business, experience of the class to whom it is specially, we might almost say exclusively, desirable to impart sound technical knowledge.

And when one asks the question, What in reality is this class? the difficulties attendant upon the question of the general diffusion of technical knowledge begin to be apparent. For the class is simply the great body of workmen throughout the country, producing by their daily and arduous labour the numerous articles which go to make up what are called the manufactures and trade products of Great Britain. The name of these is "legion," constituting by far the majority of the population. Not only are the members of this class numerous to a degree far beyond what many think of, but they are scattered here and there all over the country. In some districts, which are so exclusively devoted to technical work that they get the specific name of "manufacturing," the workmen are congregated in dense masses; in others they are more thinly and widely spread; and in some they are met with only in small bodies, almost isolated in locality from others. This position of matters is simply a fact—and we have to deal with facts as they are—and it is from this fact that arises the practical difficulty in solving this important question: How best to impart to the vast body of technical workers that education calculated to improve their working capacity, so as to enable them to maintain that supremacy which they enjoyed so long as the producers or makers of the world.

THE IRON MAKER.

The Details of his Work and the Principles of its Processes.

CHAPTER VII.

The following are the insoluble constituents of the Cleveland iron ore, which we noticed at end of last chapter: Silica, 1·50; Alumina, ·10; Peroxide of iron, 3·60; Lime iron, ·05; Magnesic sulphur, ·06; Potash, ·27; Percentage of metallic iron, 33·62. It will be perceived that, compared with the carbonates, and still more favourably with the hæmatites presently to be noticed, the Cleveland ores are rich in phosphoric acid. Practically this results in giving to them so high a percentage of phosphorus—a most debasing element, as we have already noticed—as 1¼ to 1½ per cent.

Practically the richest of our native ores are the "Red Hæmatites," the chief *locale* of which is in Lancashire and Cumberland: in the latter county their abundance has given rise, within a period of not much over a quarter of a century, to an extraordinary development of the iron trade in the district of Ulverstone, of which Barrow-in-Furness is the chief town. The rapid rise of this now large and densely populated town, returning a member to parliament, is perhaps the most striking evidence of what commercial power there is in the fact that a district possesses a good supply of some material or substance, such as iron, useful in the industrial arts. The ore takes its first distinctive name—separating it from the poorer iron ores known as the "Brown Hæmatites"—from the deep red colour it possesses. It is so soft that the ore may be used to mark objects, just as chalk is used. While abundant in our own country, in other districts than Lancashire or Cumberland—such as in Devonshire and the adjacent county of Cornwall, in Glamorganshire, in Ayrshire in Scotland, and in the north of Ireland—it is specially abundant in some districts of the Continent, such as at Bilbao in Spain, and in Norway. It is met with largely in America, and in many other districts and countries. The following is the analysis of a specimen of Red Hæmatite: Peroxide of iron, 93·35; Alumina, ·40; Phosphoric acid, ·12; Percentage of metallic iron, 65·30. Particularly low in phosphorus, the red hæmatite was from an early period used largely, and still is, for steel making on the Bessemer process. We have seen that Cleveland iron—a much cheaper ore—now competes successfully with the red hæmatites.

The ores known as "Brown Hæmatites" are in this country chiefly represented by the Northamptonshire ores and those of the Forest of Dean. The brown hæmatites are generally mixed with earthy matter, and have a large percentage of phosphorus, as will be seen from the following analysis: Protoxide of iron 73·70; Alumina, ·87; Protoxide of manganese, ·74; Lime, 1·13; Magnesia, ·17; Carbonic acid, ·16; Moisture, 4·89; Combined water, 11·20; Phosphoric acid, 1·31; Silica (insoluble), 5·47; Percentage of metallic iron, 53·34.

We have said that under the new *régime* of quick, cheap, and easy transport of the times we live in, ores of iron are imported into England from a wide range of countries—the chief being Continental, others even in the New World and the Antipodes. The richest ore we thus obtain belongs to the class known as "magnetic oxides" or "magnetic ores." They are represented in this country, being found in North Wales, Devonshire, and Yorkshire, but not in sufficient quantity to make them commercially valuable and available. The chief Continental districts for these magnetites are in Norway, Sweden, and Russia; they are found in India, the United States, and, in the form of a species of sand, in enormous bulk in our own province of Canada and in the colony of New Zealand. The Swedish iron has long been known as, and still is, the finest of all our wrought irons: hence its almost exclusive use in the manufacture of tool steels. (See the papers under the title of the "Steel Maker.") Magnetic ore is dense in mass, of a deep dark, or rather black colour, possessed of a kind of metallic lustre, and is more or less highly magnetic. As crystals they are often highly magnetic, and form what every one has heard of—"loadstones." When the ore is in its purest condition it yields the richest metallic iron, possessed of great ease in working; hence it was the ore used in the primitive days of the iron manufacture. An analysis of one sample shows the following constituents: Peroxide of iron, 67·78; Protoxide of iron, 29·05; Peroxide of manganese, ·05; Lime, 7·94; Magnesia, 2·05; Combined water, ·31; Percentage of metallic iron, 70·04. This happens to be a very rich specimen: the percentage of metallic iron may be put down much lower—as 54.

General Character of the Process of Reducing or Smelting Iron Ore.

Having given brief descriptions showing the characteristics of the iron ores used in this country in the manufacture of iron, and analyses of their constituents, we now are prepared to enter into the details of the manufacture itself. We have said that the two forms in which the iron of commerce is met with amongst us are, first, cast iron—in the trade almost always termed pig iron—and wrought iron, otherwise and popularly called "malleable iron." As wrought iron as generally made may be called, and indeed is, a secondary product, and is the result of treating cast iron in certain ways, it is of course necessary to describe in the first instance the manufacture of cast or pig iron, which thus takes the place of the primary product of the iron manufacture in its generic sense.

It is scarcely necessary, we should think, to inform any one of our readers that metallic iron—or iron, to use the term by which it is universally called and known—is produced by acting on the ores by heat. One knowing but little of metallurgy, from what we have said of the ores, and from what they know of such a familiar object as " a lump of iron," may fairly and correctly conjecture that this heat will require to be very great, and in all probability long continued, in its action upon the ores. This obviously necessitates the employment of a furnace, and one the special design of which will be such as to insure not only the easy creation but the steady maintenance of the high temperature required, and the facility in maintaining or keeping up the supply of the ore to, and the withdrawal of the resulting produce of the process —that is, the formed iron—from its interior.

A very little consideration will show to those uninitiated in metallurgy that the "ore," from its nature, cannot itself be combustible. It may, as in the case of the Black-band ores, possess a large percentage of coaly matter which may aid combustion; but *per se*, an ore to be heated possesses no qualification by which it can be made to heat itself. This condition clearly demands that in the process of "reducing" the ore, or "smelting," as it is also termed, a fuel of some kind or another will be required. Further, the uninitiated reader requires to be told, although he may by some thinking over the subject conjecture the fact, that to facilitate the "reduction" or "smelting" of the ore a substance known as a "flux" is used. This flux is lime. To keep up the intense heat required in the furnace, a blast of air, produced by what is called a blowing engine, is used—hence the term "blast furnace" applied to that form used in the manufacture of cast or pig iron. We shall hereafter go more fully into the details of the processes actually gone through in a furnace during the reduction or smelting of the ore within it; meanwhile we simply state that the three materials—the fuel, the flux, and the ore—are placed within the furnace in a certain way, and the heat maintained by the continued blast. Before coming to consider the action of the furnace and the behaviour of its carbonised materials, it will be necessary to glance briefly at the three substances—the fuel, flux, and ore.

Fuel used in Reducing or Smelting Iron Ores.

We now take up a most important part of our subject—fuel; for upon the quality and abundance or otherwise of the fuel employed, the quality of iron produced, as well as the yield obtainable per week, largely depends. The essential constituent of all fuel is, of course, the element *carbon*; in its purest form, as practically used, it exists as wood-charcoal, and it is for this reason that wood-charcoal presents the best fuel for the purposes of the blast furnace; it may therefore be looked upon as the "type" of fuel, and may be taken as a standard from which the value of other fuels, as coal or coke, may be determined. There are a great number or varieties of fuel ordinarily employed, but that giving the most pure iron and the most valuable, —iron that is used only in the manufacture of very fine articles—is the expensive wood charcoal. This form of carbon is of course very much too costly to be made extensive use of in the making of articles of utility that are manufactured on an enormous scale; for such purposes the most suitable material is good coke or charred bituminous coal. Coke is almost universally employed in England for this purpose. Such is the case in this country; it is different in America, where wood in some districts is as cheap as it is dear here, and the Americans now largely make use of wood-charcoal as fuel. Wood-charcoal is, notwithstanding, still sparingly used, we believe, in one or two of our own districts, such as in Newlands, in Ulverstone, and at Inverary. On account of the great quantity of moisture and of mineral substances contained in *peat*, that form of fuel is not applicable to the manufacture of iron. So also is stone-coal or anthracite unsuitable for the blast furnace, because, being so extremely compact, combustion proceeds far too slowly. What is called hard coal, if not bituminous or hard, is frequently employed: it is generally considered inferior, hewever, to first-class coke: indeed, raw bituminous coal is not suitable for the blast furnace, owing to its great tendency to form into cakes, or "crosil" together, as the technical expression goes. For precisely the same reason, very soft coal is unsuitable.

As already stated, the chief material used as fuel in the smelting of iron ores is, in England, *coke*; and, although inferior to wood-charcoal, it is much cheaper and more convenient in use. Coal is, however, still largely employed; and especially is this the case in Scotland. Thus, for example, in a blast furnace in the Glasgow district coal obtained from the Lightmoor Works, Shropshire, and known as "clod coal," gave a production of a ton of iron in the furnace to three tons of coal by cold blast—the loss sustained in coking amounting to 45 per cent. Another variety of coal from the same district and used in the same furnace yielded only a ton of iron for every five or five and a-half tons of coal, the loss in coking being 50 per cent. The former coal was a *soft* variety, a horizontal section of it exhibiting pores completely filled up with carbonaceous matter; the second variety of coal was rather hard, and transverse divisions were filled with calcareous matter. These two examples will convey a tolerably accurate idea of the influence which the mere hardness or softness of the coal has upon the quantity required for the production of each ton of iron.

Mineral or pit coal has only been comparatively recently used extensively as a furnace fuel. The chief English districts for this coal are Staffordshire, Yorkshire, Northumberland, Durham, Lancashire, and Cheshire. In Scotland, also, North and South Wales, and certain parts of Ireland, it is very abundant. This coal is very rich in carbon; it exists, like the last variety, in different forms. The following table shows the composition of coals from Wales, Newcastle, and from Scotland, and is taken from the "Third official Report on the Coals suited for the Royal Naval Steamers."

	Wales.	Newcastle.	Scotland.
Carbon	89·78	84·92	76·09
Hydrogen	5·15	4·53	5·22
Sulphur	1·02	·65	1·53
Nitrogen	2·16	·96	1·41
Oxygen	·39	6·66	5·05
Ash .	1·5	2·28	10·7

In the following table are given analyses by Mr. Riley of blast-furnace coals and of their ashes. In both tables the figures denote: 1. Dowlais upper 4-ft. coal; 2. Dowlais Ras gas coal; 3. Bargoid big coal; 4. Torno Yard coal,—and *ash* of these coals in the second table.

	Welsh.				Staffordshire.	
	1	2	3	4	Coal.	Coke.
Carbon	89·50	88·13	87·62	82·60	76·32	85·14
Hydrogen	4·37	4·37	4·34	4·28	5·18	·78
Nitrogen	1·25	1·41	1·13	1·28	1·38	
Oxygen	3·14	2·94	2·53	3·44	10·74	1·24
Sulphur	·54	1·01	1·06	1·27	1·01	2·16
Ash .	1·20	2·00	3·32	7·18	5·37	10·68
	100·00	100·00	100·00	100·00	100·00	100·00

			3	4
Silica . .	35·73	24·18	37·61	39·64
Alumina .	41·11	20·82	38·48	39·20
Peroxide of iron	11·15	26·00	14·78	11·84
Lime . .	2·75	9·38	2·53	1·81
Magnesia .	2·65	9·74	2·71	2·58
Sulphuric acid	4·45	8·37	·29	—
Phosphoric acid		·21	2·00	3·01
Sulphur .		·14		—
Iron . .		·24		—
	98·83	99·08	98·40	98·38
Metallic Iron	7·80	18·58	10·30	8·28

It is a disputed point among authorities whether coke or coal is, in the end, the more economical fuel to use in smelting. Sir Lowthian Bell, the great authority on blast furnace management, gives it as his opinion that where the caking property already referred to is absent, there is an advantage in using raw coal, "for it is immaterial," says this eminent authority, "whether the loss of a portion of the fixed carbon takes place in the furnace or in the coke oven, and under any circumstances, the labour and other expenses connected with coking are avoided when the fuel goes direct from the mine into the furnace." In the Cleveland district coke is chiefly used. "This arises from the fact," says Sir L. Bell, "that the produce of the Durham coalfield is so bituminous that in the raw state it offers insurmountable difficulties by impeding the free passage of the blast and thus preventing the regular descent of the contents of the furnace." This reason, indeed, will be found frequently to be the cause of the employment of coke in preference to coal in so many of our English iron-smelting districts. When the coking is done in an oven such that no fixed carbon is lost, *then* there is an advantage in coking, but, as it is, from coal containing, say, 70 per cent. of fixed carbon, only about 62 per cent. of coke is obtained. Thus it would seem that, unless further improvement in the construction of coke ovens be made, it is not advantageous to coke previously. Then, again, when raw coal is used in the furnace, the resulting gases are wasted, so far as the furnace itself is concerned; when coke is employed these gases are utilised in the recent improved ovens. The latter method—employment of *coked* fuel done in improved ovens—is in Mr. C. W. Siemens' opinion the best. The following may be given as an instance of the comparative values of coke and coal. At the Clyde Iron Works, near Glasgow, in 1829, 3 tons of coke was found to do just as much work by cold air blast as 6 tons 13 cwt. of coal; while again by hot blast, at 450° Fahr., 1 ton 18 cwt. of coke was found equal to 4 tons 6 cwt. of coal.

Again, experiments by Mr. Phillips, on the comparative values of fuel, which, although not having special reference to smelting, still bear on the subject. show that while 1 lb. anthracite from Glamorganshire will raise 75·73 lb. of water from 32° Fahr. to 212°, 1 lb. of coke from Durham coal raised 71·59 lb.

We have referred above to Durham coke: the following analysis of that used at Askam, Barrow-in-Furness district, is given by Mr. William Crossley, in the paper we have already referred to.

ANALYSIS OF DURHAM COKE.

Sulphur	·70
Ash	5·00
Moisture and loss	·92
Carbon (by difference)	93·38
	100·00

Fluxes used in the Blast Furnace for the Reduction of the Ore.

In order to the reduction of iron ores it is necessary that there should be present some substance which is capable of ready union with the *mineral* impurities of the ore. These earthy or mineral constituents generally consist of various admixtures of oxides of silicon and aluminum and other metals. The substance which is provided for the removal of these substances is termed a *flux*; by the union of the latter with the former a compound is formed which is in essential characters a sort of fusible *glass*. The materials most commonly used as blast-furnace fluxes are limestone, chalk or calcareous spar, and quicklime; in certain cases also, as when the ore to be reduced is of a calcareous nature, the addition of other substances is found to be useful, as a proper proportion of clay or sand, etc. The carbonate of lime or limestone, as a flux, gives up its carbonic acid as it becomes heated in the furnace; the consequence is the formation of caustic lime. Now, it is this latter substance, and not the carbonate of lime itself, that unites with the silica and alumina of the ore. The compound formed is a double silicate of lime and alumina. The flux used at the Askam furnaces consists of limestone; the following table shows its composition:--

ANALYSIS OF STAINTON LIMESTONE.

Carbonate of lime	95·00
Carbonate of magnesia	4·20
Silica	0·50
Oxide of iron and alumina	·30
	100·00

Carbonate of lime in an almost pure state is used as flux in the Cleveland district. It contains some 56 per cent. of caustic lime combined with 44 per cent. of carbonic acid.

Limestone is sometimes used "raw," and sometimes in the calcined or roasted state; and just as we have seen a great diversity of opinion to exist as to the advantage of using raw or roasted ore, so also authorities are at issue as regards the comparative advantages of the two methods. Nearly as much heat (5000 centigrade units) is employed in expelling the carbonic acid from the raw limestone as there is (5300 centigrade units), in reducing this carbonic acid to the lower oxide—carbonic oxide. This heat is equal to, according to Sir Lowthian Bell, 3 cwt. of coke per ton of iron produced; but *practically* the use of calcined limestone is never attended by such a saving of fuel. The same authority accounts for this latter circumstance in the following manner. "In the upper region of a blast furnace there is a space where carbonic acid up to a certain proportion, say 40 volumes of carbonic acid to 100 of carbonic oxide, does no harm, because neither is the temperature in that region high enough for enabling it to take up carbon from the coke in the presence of so large an excess of carbonic oxide, nor is there any metallic iron present in that part of the furnace which the carbonic acid could oxidise." When raw limestone is employed the heat in this space is not high enough to drive off this carbonic acid: so that it is only expelled when the lower and hotter part of the furnace is reached. But the heat which is enough to expel the carbonic acid from the flux is sufficient to convert it into carbonic oxide by the incandescent carbon there present, and for this latter work more heat is required. Previous calcination, however, does not save this heat as well as that required to obtain the carbonic acid at first, because caustic lime (which is formed, as we have already stated when raw limestone is used) attracts less carbonic acid at a very high temperature.

"The use of calcined limestone," says Sir Lowthian Bell, "requires the combustion of a sufficient quantity of small coal outside the blast furnace to drive off the carbonic acid from the limestone; and also the combustion of a sufficient quantity of coke inside the furnace for reducing to carbonic oxide the smaller quantity of carbonic acid, which has subseqnently been taken up again in the furnace by the calcined limestone." Then, in regard to the use of raw limestone, he sums up by saying that it necessitates "the combustion of a sufficient quantity of coke inside the furnace, both to drive off the carbonic acid from the limestone and to reduce it to carbonic oxide." The conclusion is that previous calcination effects a small economy as regards cost, but none whatever so far as the *heat* is concerned.

"Charge" of the Blast Furnace.

We now come to the "charge" of the blast furnace in the making of cast iron. The three classes of materials used in the manufacture of "pig iron" or "cast iron"—the ore which yields the iron, the flux by which the process of smelting is aided, and the fuel which supplies the high degree of heat required to act upon them both, and to produce what may be called the chemical combination effected in the interior of the furnace—are placed in its interior in certain proportions. It may easily be conceived that those proportions vary, not merely from the different views held by different makers, but from the circumstance that the materials of the "charge" vary in kind and quality according to the district. We can here, therefore, but indicate in a general way the proportion of a "charge," by which name the combination of the three varieties of material used is known.

In the Askam (Cleveland district) furnaces each ton of pig iron requires about six tons of those materials, composed as follows:—

	Tons.	
Cleveland ironstone.	350.	4·25 tons raw material besides fuel.
Limestone . . .	0·75	
Coke.	1·30	1·8 ton fuel.
Coal.	0·50	
	6·05	

THE YOUNG ARCHITECT OR ENGINEER.

HIS STUDIES—OFFICE DUTIES—AND PRACTICAL WORK IN THE PREPARATION OF WORKING DRAWINGS, OF SPECIFICATIONS, AND CONTRACTS FOR WORK.

CHAPTER XI.

AT the close of last chapter we commenced our specimen of the general conditions attached to specifications by naming that the specifications and the drawings are to be considered as constituting one document only. "But should there be any work to be done, or materials to be provided, which may not be named in the specification or delineated or shown in the drawings, but which according to usual custom or general practice are considered necessary for completion of the works, the contractor or constructor is not by virtue of or under cover of this omission to consider himself absolved from doing the work or providing the materials. But, on the contrary, it is expressly to be understood, and is hereby provided as one of the essential conditions upon which the contract is based, and upon which the works are to be done, that the contractor or contractors must include the work to be done and the materials to be provided in his tender as if both or either of them had been precisely and accurately shown in the drawings and clearly stated in the specification. The contractor or contractors, in the spirit of this last-named condition, must consider himself or themselves to be, and he is or they are hereby bound, and must bind himself or themselves, to execute and to find generally and supply whatsoever in the way of work or material may be found necessary to complete the works according to the true and recognised meaning and generally received purport of the drawings and specification. And should, at any time during the progress of the works, any point arise which may give occasion for doubt or dispute in connection with the above point, or in connection with any other point involved in the execution or carrying on or out of the works, the point or points which may give rise to doubt or dispute are to be left to the decision of the architects, and which given in writing is to be final and without appeal. From the commencement of the works to the complete and final finishing of the same in every detail, the care of the same and whatever appertains thereto is held to be or lie with the contractor or contractors, or the several contractors preparing work under him or them, who are each and all in his or their respective department or departments to protect and preserve the same. And in the case of any damage or injury happening to any part of the works being carried on—by the workmen employed, by wilful and malicious destruction or by careless and thoughtless workmanship, or by the inclemency of the weather, or by fire, or by any cause or accident whatever, the contractor, or any one or all of the contractors whom it may concern, or in whose department the injury is done, or with whom the accident occurs, shall make good, repair, or supply the same at his cost or their cost. So that at the conclusion of the several works every part of the whole work may be complete and perfect, to the thorough satisfaction of the architect. And it is one of the conditions upon which the contract is based, and upon which all its work is to be executed, that in no case or at no time is the proprietor or owner of the house or structure being erected to be made chargeable for anything lost, stolen, destroyed or damaged. And further, it is one of the conditions upon which the contract is based, and upon which all the works under it are to be executed, that the proprietor or owner of the property shall have the right through his architect of making such alterations in or additions to the several works as they proceed without nullifying or invalidating the contract. The value of such alterations or additions is to be ascertained by the architect, in which case the contractor is to deliver to him or to the clerk of works a statement every day of the time and materials for such additions, and in default of the same such extra charge will not be allowed and paid for. And such extra works shall be previously contracted for as the architect may deem fit, and the amount to be paid or deducted as the case may be. But it is to be understood that the proprietor will not feel himself bound by any orders which may be said to have been given verbally for any such alterations or additions, and consequently no allowance will be made for any such works, except the contractor or contractors can produce a written order to that effect signed by the architect.

"It shall be in the power of the architect or clerk of works to reject and cause to be removed any part of the materials or workmanship, which either or both of them may consider improper and unworkmanlike, upon first giving the contractor two days' notice in writing to that effect. And in the event of the contractor refusing or delaying to rectify or refusing to comply with the orders so given to him in writing, or if on the other hand the contractor shall perform all or any part of the work in an improper, careless, slovenly or incomplete manner, or in case the works be not proceeded with with all due speed or proper despatch, then in all or any of such cases the proprietor or owner through his architect shall have power and be at full liberty to suspend the further execution of the works by the said contractor. After having given six days' notice in writing to that effect he [illegible] to have the power to take the contract out of his hands and employ and engage any other person or persons, subject to the terms of the original contract, to duly perform and execute it. In the event of this case happening, the costs and charges thereof shall be paid or allowed under certified statement by the architect to the proprietor by the original contractor or contractors, or by his or by their sureties, or deducted from the money which may be due at the date on which the said contract is taken out of his or their hands. It is distinctly understood that the works are to be commenced immediately after the signing of the contract, and the whole to be completed to the entire satisfaction of the architect on or before the day of , one thousand eight hundred and .

"But if the works be not completed by the date here named, the contractor is or the contractors are to forfeit and pay the sum of shillings per day for each and every day exceeding the date herein stated, until the entire completion of the several works to the satisfaction of the architect as aforesaid. The payments to be made in instalments of £ , each payable at such times as the architect shall consider the contractor has been sufficiently advanced and work completed in excess to the extent of one-fifth of the amount so advanced or of instalments paid.

"It is also to be distinctly understood as one of the conditions that the building from its commencement to its finishing or completion to the satisfaction of the architect, and the materials placed on the land, are to be considered as in the possession of the proprietor, without tending to make void or invalidating any of the foregoing conditions, or making him liable to risk or damage of whatsoever description. And the contractor is to deliver the buildings up to the proprietor at the completion of the works in a clean and perfect condition.

"The contractor is or the contractors are to provide at his or their cost or charges a complete set of tracings—upon tracing cloth in order to stand wear and tear—of the various drawings prepared by the architect, and to provide with lock and key a suitable box to receive them, and which box with its contents of tracings is to be fitted up in such convenient and prominent place as to be within ready reach when the tracings are required or any one of them for the purposes of reference during the progress of the works. The proprietor, the architect, and the contractor or contractors, each and all of them, to be provided with a key to the said box, so that any one of them can have access to the tracings should the others be absent from the grounds.

"And with reference to the drawings provided by the architect, it is to be understood as one of the conditions upon which the contract is based, that where there happens to be any discrepancy between the figures which give dimensions and measurements as written or printed upon the drawings, and such measurements or dimensions in the drawings as may be judged by and taken from the scale or scales attached to and forming part of the drawings, then the figures on the drawings are in all cases to be preferred. And it is also to be understood that along with the complete set of tracings of the drawings before referred to as to be kept on the premises or grounds in a box, a copy certified by the architect to be correct of the specification is to be deposited, as also a certified copy of the present conditions. The tracings are also to be certified by the architect as correct, before they are delivered to the contractor or contractors to be deposited in the box on the grounds or premises aforesaid."

Conditions attached to Specifications (*continued*).

The following is an example of a specification adapted for a villa or detached house, such as we have illustrated in figs. 1 to 10 inclusive. In specifications for buildings of a superior class, where the clauses are numerous, it is a good plan in drawing them up to provide "marginal references," pointing out the position of the various leading clauses. This is illustrated in the specification we give, and is a method well calculated to facilitate ready reference when the specification is to be consulted during the progress of the works.

SPECIFICATION of work required in the erection of a villa or detached residence, in accordance with the plans, elevations, sections, and detailed drawings accompanying this specification and numbered consecutively from 1 to inclusive.

EXCAVATOR'S WORK.

Footings.

Surface soil.

Concrete in foundations.

To dig out the ground and the footing trenches, where necessary for the several walls, cellars, drains, as shown on plans, and fill in and well ram the same, as the different walls are carried up. To cart away all superfluous earth and deposit it where the architect or his clerk of works (if any) may direct. The whole of the surface earth (if suitable) to be reserved and afterwards spread evenly and uniformly over garden and lawn. All water that may arise from springs, rain, or any other cause, must be removed from all the excavations as soon as discovered, and not allowed to settle and remain there. The concrete under all walls where shown to be in no part less than one foot thick and double the width of the lowest course of footings. The concrete to be made of good clean gravel or small stones or broken brick (none of the pieces to be larger than to pass through a ¼-inch sieve mesh) and of Portland cement, in the proportion of three parts of gravel, small stones or broken brick, to one of cement. The whole to be thoroughly incorporated in a dry state, and the water added by degrees. The concrete where used to be tipped into the trenches from the highest possible point.

BRICKLAYER'S WORK.

Kind and quality of bricks.

The whole of the bricks used throughout the building to be of the best description of stock bricks, sound, hard, and well burnt; no "place" bricks or any which are soft or unsound to be used in any part of the works.

Mortar.

The mortar to consist of grey stone lime, and clean, sharp-screened and well-washed river sand, free from all impurities, in the proportion of three parts of sand to one of lime; the lime and sand to be carefully mixed together and afterwards passed through a pug mill twice or thrice, to be thoroughly incorporated.

Walls.

The walls are to be built in regular courses, bond (see the papers on "The Bricklayer" for description of varieties of bond), and of the different lengths and thicknesses shown in the drawings. No four courses shall exceed thirteen inches in height, and the whole to be carried up in a regular manner. The mortar used throughout to be of such consistency that the workman may be enabled to flush up each joint full and sound, and course by course. No "toothing" to connect other walls to be left, but the walls are to be worked back and properly bonded.

Footings.

The footings are to be in three courses; the lowest course must be twice the thickness of the superincumbent wall built upon the footings. The bricks used in the building of the footings to be all carefully selected, the hardest and soundest; and no "bats" are in any case to be used.

Window openings or voids.

The window splays to be neatly cut and all quoins accurately formed. The walls on top floor to be set or splayed back or recessed to receive the wall plate, timbers, etc., of roof truss. All "putlog" holes to be carefully filled in;

Defective bricks to be taken out.

and if after the completion of the works any defect in bricks should show, or efflorescence or splitting take place, the defective bricks must be taken out and new ones substituted, thoroughly sound and good.

String courses.

To form all projections for strings, plinths, and cement runnings, and securely tie in the same. To carry out all corbellings for fireplaces and bearings for timbers. To properly bed and secure all lintels, wall plates, and templates.

Arches.

Arches, in nine-inch work, to be turned over all lintels and openings, unless otherwise shown in drawings, in half-brick rings, with joints properly broken. Nine-inch arches in cement with bricks set in "Portland" to be turned over cellars, the spandrils to be filled in with hard, dry "rubble" work. Properly form core, and carefully parget all flues.

Flues.

The dimensions of the same to be not less than 14 × 9 in. for the ordinary rooms, and 18 × 14 in. for kitchen fireplace;

Trimmer arches.

4½-in. arches to be turned to all fireplaces, and "trimmer arches" to all hearthstones except those on basement or cellar floor. Build in boiler and furnace in scullery with all necessary fire-bricks, the external face to be carried up with hard, sound bricks, neatly tuck pointed, and with "bull-nosed" or rounded bricks at corners.

Fireplaces.

Fix all grates throughout house, finding and setting in loam all necessary fire-lumps and fire-bricks, which must be of the very best description.

Drain tubes to water-closets.

Provide and lay from water-closets 6-in. glazed stoneware pipes, properly jointed in cement, laid with a gradient fall or incline of 2 in. in every 10 ft., and securely connected with sewer; the remainder of the pipe to be 4 in. in diameter, laid with a sufficient fall, and jointed as before; all necessary bends, junctions, and siphon traps to be found and properly fixed and laid.

Cellar floors.

The cellar to be paved with hard, dry bricks, laid in mortar on a properly prepared bed of hard, dry rubble, or, by preference, with Portland cement concrete.

MASON'S WORK.

Qualities of stone.

All the stone to be used throughout the building to be of the best description of its kind (according to locality or class of stone selected), sound, free from all sand-holes, veins, or other defects.

Ornamental work.

The ornamental work—as string courses, window and door heads and dressings, and trusses, etc.—to be worked in freestone, each block to be laid in its own bed and properly jointed.

Steps.

The steps leading to cellar to be of tooled stone, 2 in. thick, Seton brick "risers," and properly bedded in mortar. The steps to front door to be of the best stone, 11-in. "tread," 7-in. "riser," with moulded "nosings" and properly weathered. Tooled stone steps to be placed at back door leading into garden, and to have 10-in. tread, 7-in. riser.

Floors.

The scullery and larder floors to be laid with stone paving, tooled on one face and properly jointed and bedded in mortar, no stone to have less than 9 ft. of superficies or surface.

Hearth-slabs or stones.

Two-inch "rubbed" stone hearth-slabs, of the very best quality, to be laid to drawing-room and parlour fireplaces, of the length and width as shown in drawings. "Tooled" slabs and inner hearths to kitchen and bedrooms, firmly bedded in mortar.

Slop stone.

Provide and fix in scullery a York stone slop-stone, 4 ft. long, 1 ft. 6 in. wide, and 6 in. deep, with hole cut in centre for bell trap.

THE DOMESTIC HOUSE PLANNER (*see Text*).

PLAN OF SEMI-DETACHED COTTAGES.

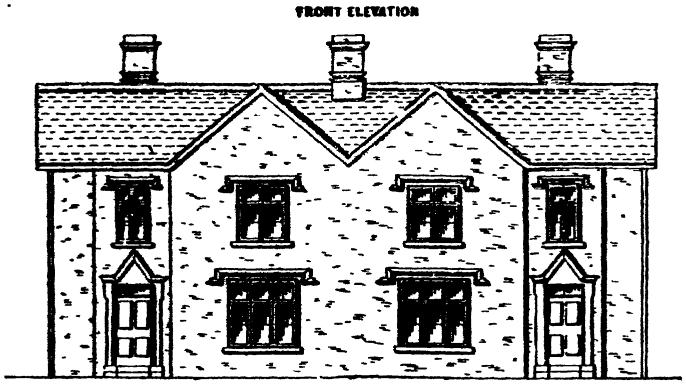
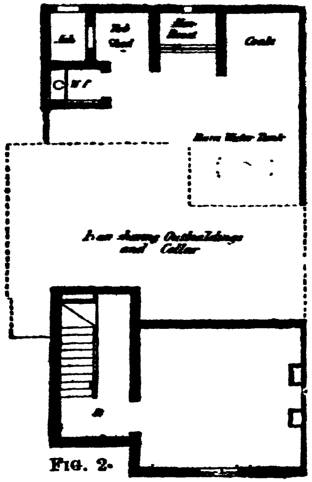


FIG. 1.



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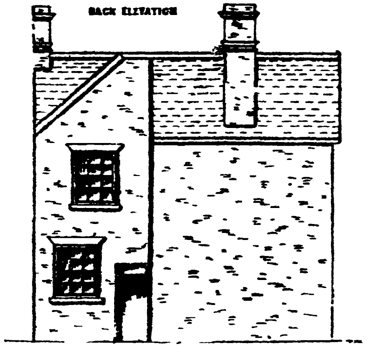
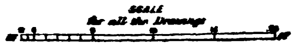


FIG. 3.



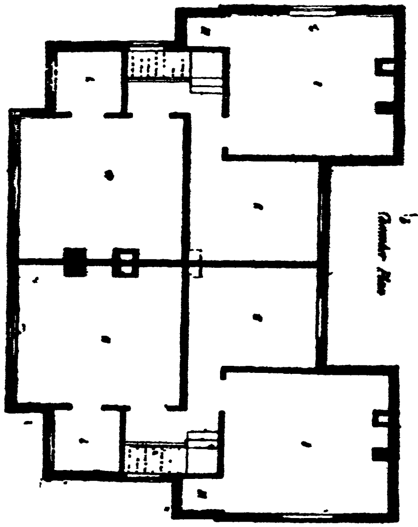
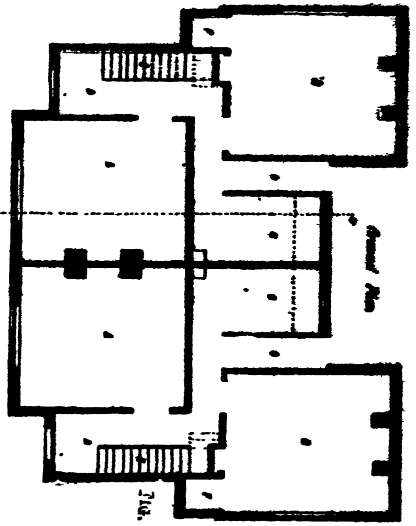


FIG. 7.



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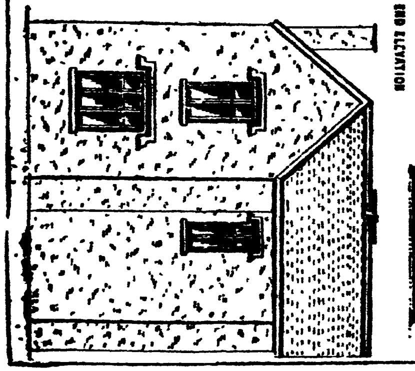

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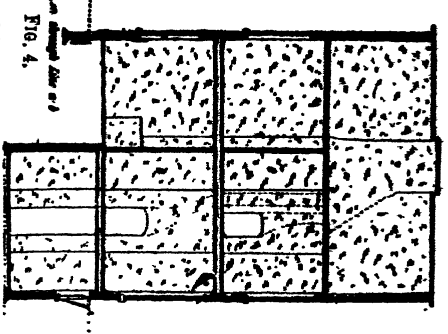
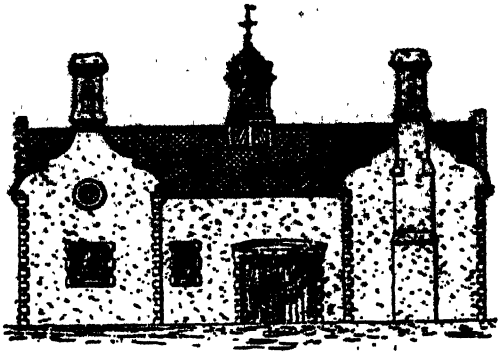


FIG. 4.

Designs for Stables. Figs. 1, 2, Style—Elizabethan; Figs. 3, 4, Domestic Gothic.

Fig. 1.



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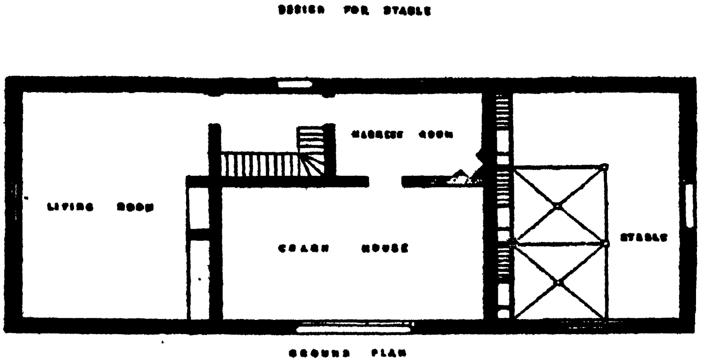


Fig. 3.

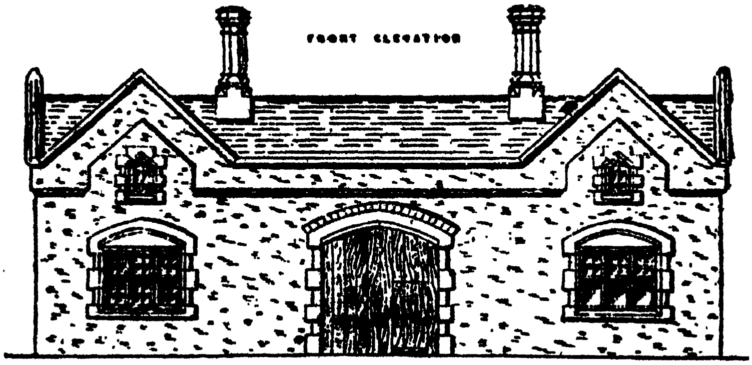


Fig. 4.

THE GARDEN ARCHITECT.

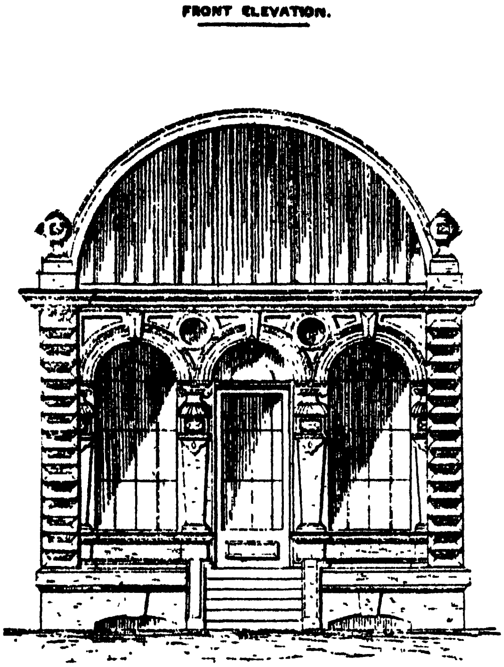


Fig. 1.

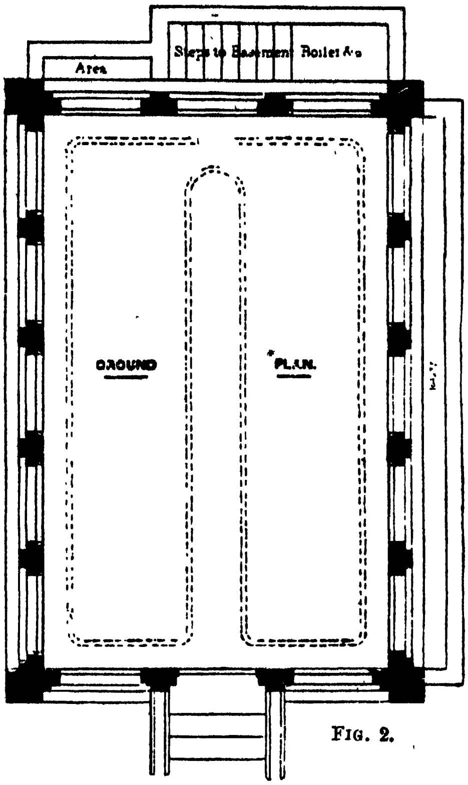


Fig. 2.

Design for Conservatory. Style—Elizabethan.

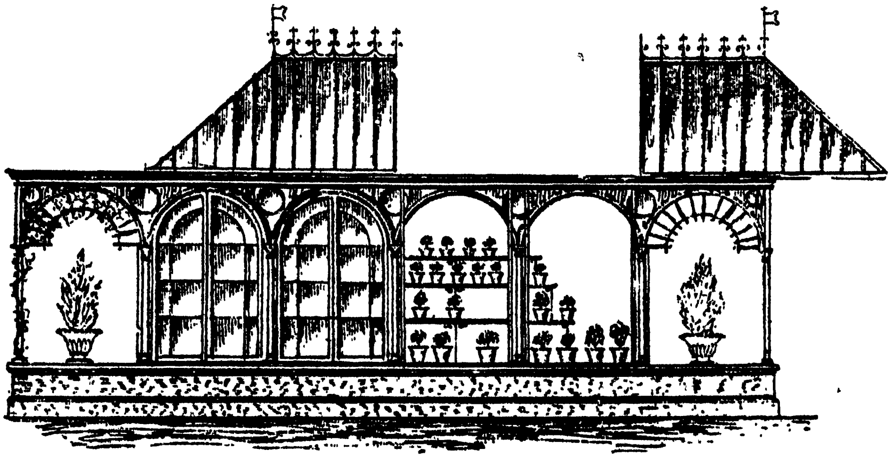


Fig. 3.

Conservatory with Patent Sliding or Rolling Roof.

STOVES AND FURNACES.

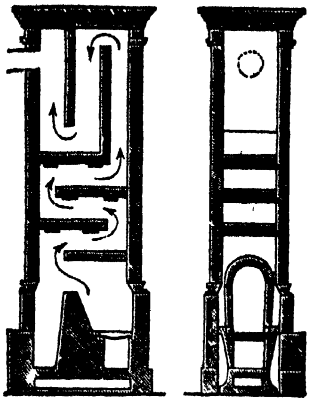
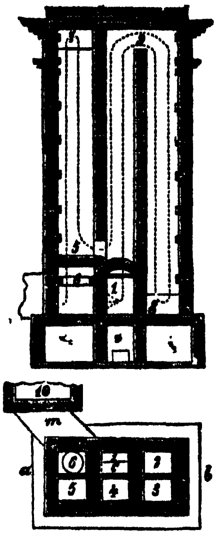


FIG. 1.



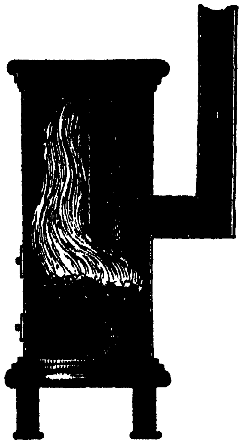
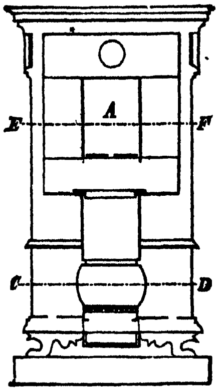


FIG. 6.



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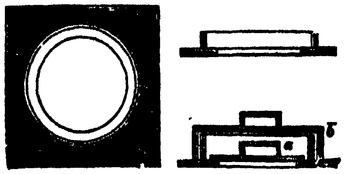

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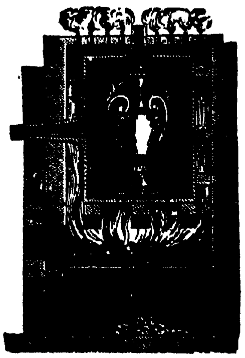

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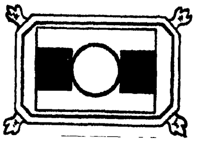

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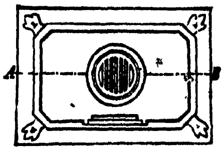

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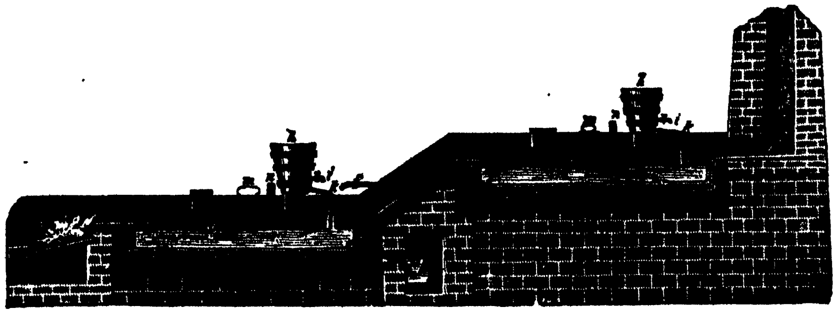
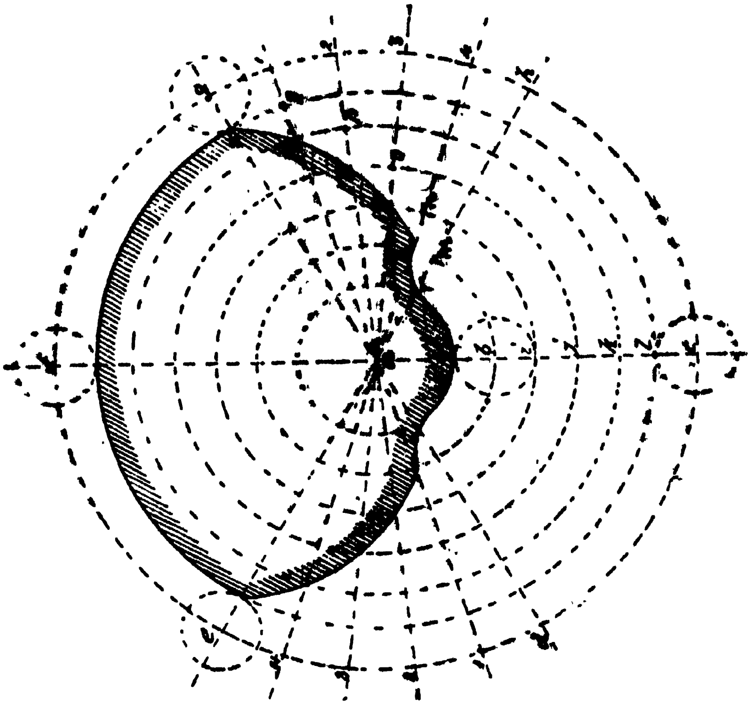


FIG. 8.

THE GEOMETRICAL DRAUGHTSMAN (see Text).



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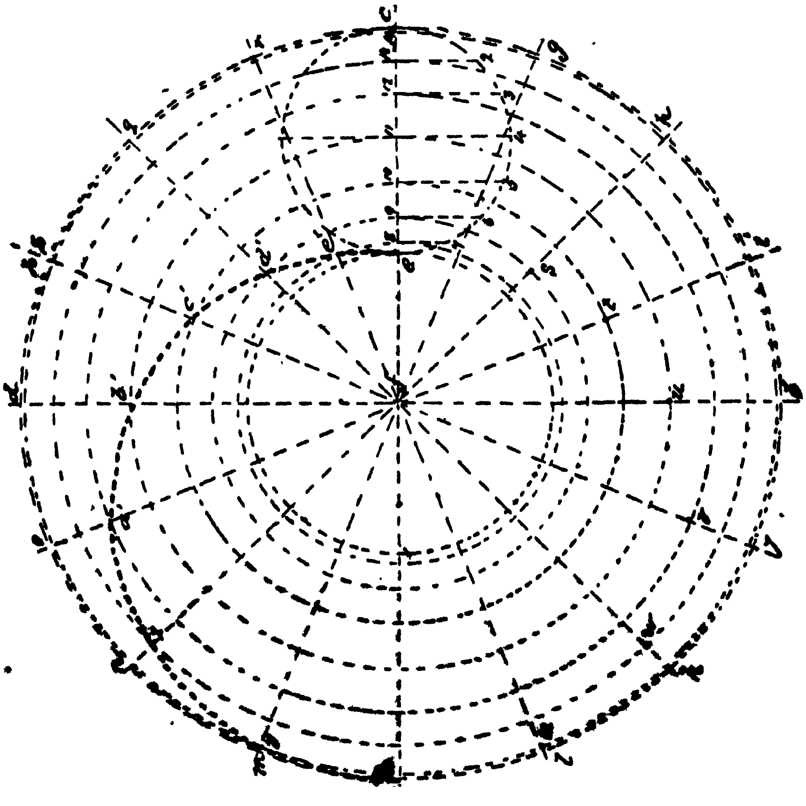
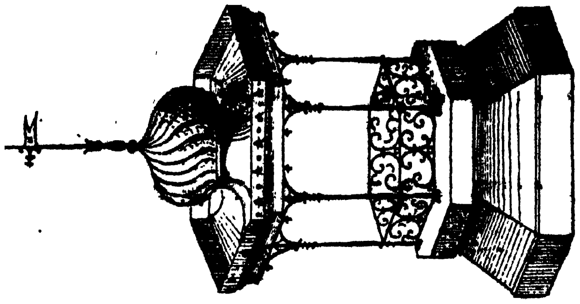


FIG. 1.

THE WORKER IN ORNAMENTAL IRON WORK.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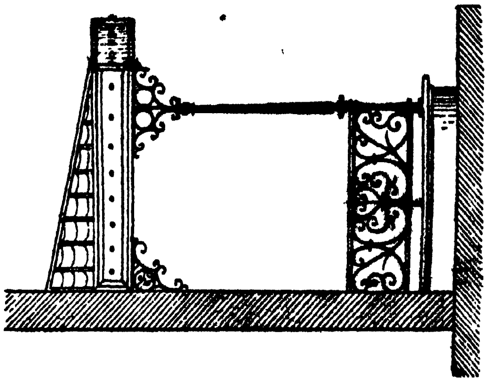
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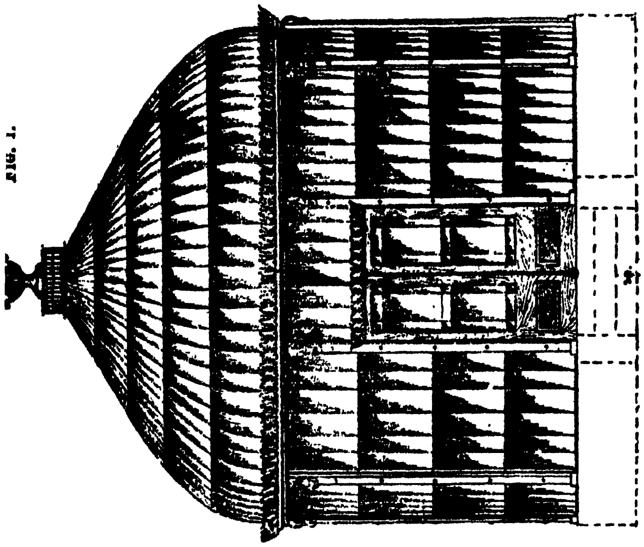
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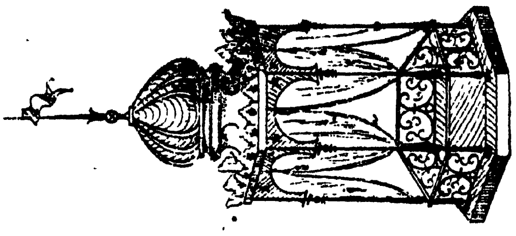
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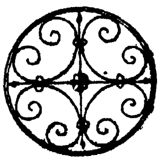

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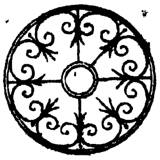

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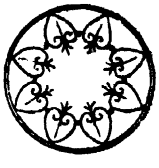


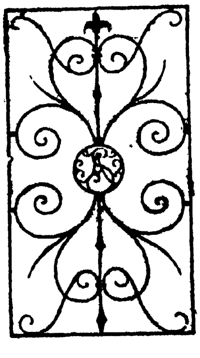


FIG. 8.

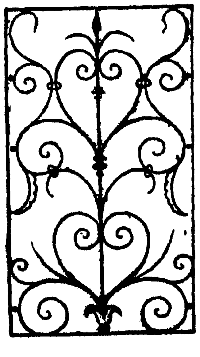


FIG. 9.

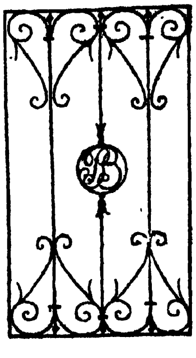
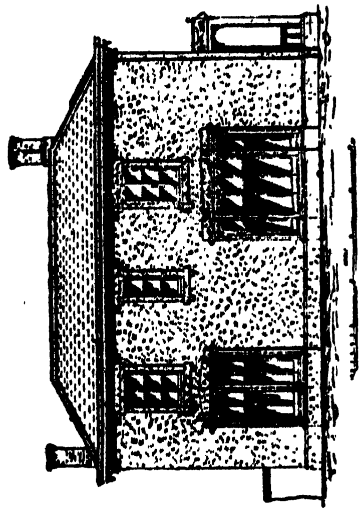


FIG. 10.

DESIGN FOR VILLA: STYLE—ITALIAN. FIG. 1, FRONT; FIG. 2, SIDE ELEVATION; FIG. 3, BASEMENT; FIG. 4, GROUND PLAN.



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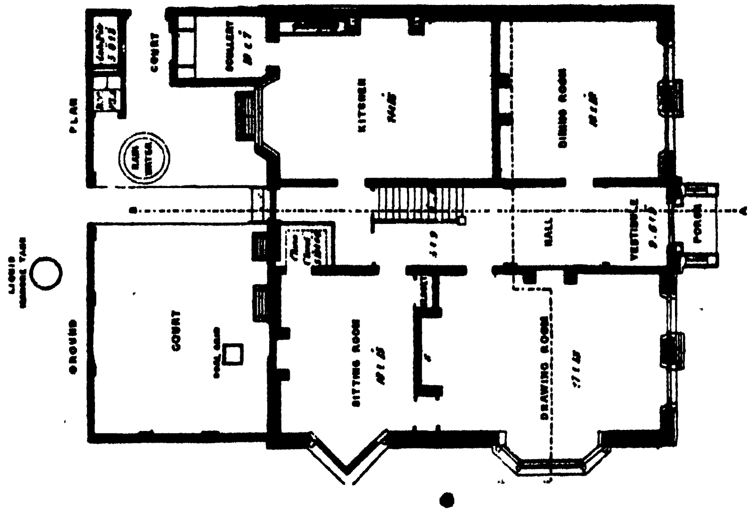

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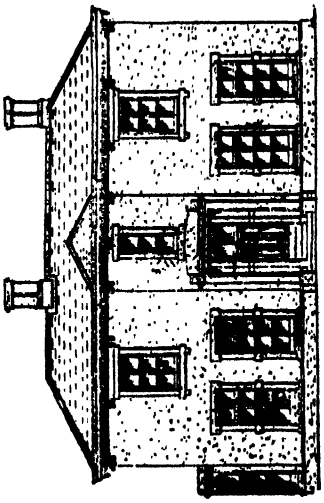
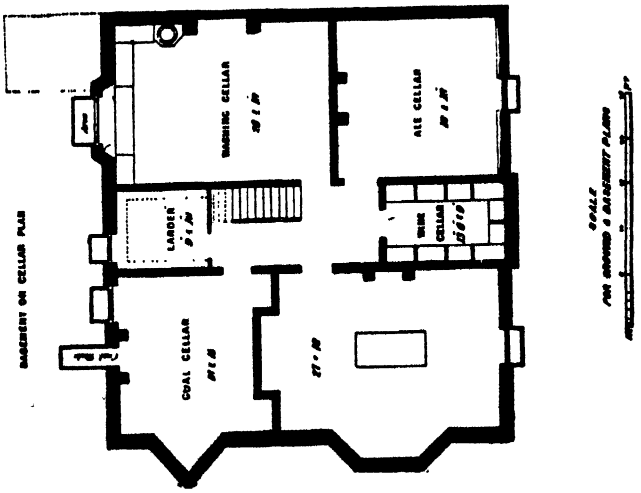




THE TECHNICAL STUDENT'S INTRODUCTION TO THE GENERAL PRINCIPLES OF MECHANICS.

LAWS AFFECTING NATURAL PHENOMENA—MATTER AND MOTION.

CHAPTER XXIV.

Elasticity.—Recoil.—Resiliency (*continued*).

IN concluding last chapter, we stated under the above head, that from the popular point of view the reader would have no difficulty in deciding whether a body was elastic or not. In grasping or touching a body he as it were so intuitively feels that it is either elastic or the reverse, that he would very likely be surprised at being asked if the one was and the other was not elastic. So assured is he in his own mind that the one tells, so to say, its own tale so readily, as against that of the other, that there is no room for doubt. But while this popular or general conception is on the whole mainly correct in its decision as to this property of general bodies, it is apt to give in some cases conceptions which are the reverse of accurate. Take any given number of people who have not received what is called a very liberal education, including in this term a knowledge of the general facts at least of science or technics, and it may be safely affirmed of them that they associate the idea of what elasticity is only with bodies which are soft and capable of compression. Thus, they can tell at once, and as they conclude with absolute accuracy, that a mass of clay is not, while one of india-rubber or of worsted is elastic. But they consider that they are quite as accurate, when they grasp or touch or attempt to press together a ball of ivory or a ball of steel, in saying that neither the one nor the other is elastic, and this simply because both bodies are very hard. At least, if pressed for a reason why they so conclude, they would possibly have a difficulty to give another reason; or perhaps many would be content to give that particular reply which is so often given in such cases—"I cannot tell why, I only know that those things are not elastic," confounding here knowledge with mere assumption or feeling. Perhaps the only exception to this popular conception that hardness is not elasticity is in the case of steel springs, the material of which is hard, but the whole body of which so arranged is elastic. But this idea in all probability flows from the mere arrangement or shape which is given to the metal; and that this is very probable may be gathered from the fact that the same mass of metal if presented to them in the form of a thick bar or a ball would be, as we have seen, pronounced or said to be non-elastic or inelastic. Just as they would pronounce a large and thick piece of whalebone to be non-elastic because it was hard and to touch or pressure apparently unyielding, while if they saw it placed so as to act as a familiar acquaintance with springs of various kinds has taught them it will act, they would at once decide that it was elastic, and thus dispute its hardness. But apart from this, which we take to be almost the only exception to the popular idea that softness or a capability to yield to pressure is an invariable concomitant of a body they say or know to be elastic, the converse conception, that hardness is a concomitant of bodies which are non-elastic, is to the popular mind borne out by a number of facts, which are to it quite conclusive, that, as a rule, hard—at least very hard bodies—are non-elastic. When they see a glass ball shivered into atoms when thrown against a wall or a stone pavement or a glass vessel, they decide at once that the glass is a non-elastic substance. In like manner, if, in place of being in the form we shall say of a watch-spring, which to the popular mind conveys the best idea of what a perfect elastic body is, they saw steel in the form of a hard ball, which when struck by a hammer flew into a number of pieces, or in the form of a bar was at once easily broken by another blow of a hammer, they would almost to a certainty conclude that it—the steel—was a non-elastic body. Now, in both cases, these conclusions would be most inaccurate, for *per se*—that is, in or by themselves—glass and steel are elastic substances, but this elasticity which they naturally possess is changed or modified by the *condition* in which they are. Thus, it is to the popular mind a somewhat difficult thing to believe that a bunch of beautifully shining hair-like substances, so elastic that it waves to and fro with every breath of passing air, and can be twisted round the wrist to form a fancy bracelet, or formed into a chaplet or wreath for the brow or the hair, is glass—the very same substance which in the form of a drinking glass or dish they know to be so weak that it is the popular embodiment or synonym for fragile weakness. And the contrast between what is the actual property of glass and what the popular conception of it is would perhaps be all the more difficult to reconcile if they saw glass in the same coiled-up or spiral form as a watch-spring of steel gives—made by a recently introduced process—of a slender hollow tube. It is, then, the condition in which the glass is that decides, so to say, whether it is to be classed as an elastic body or not; just as it is the condition of steel which decides whether it is to be an elastic body or the reverse—as tough and yielding as in the case of a watch-spring, or as brittle as glass is supposed popularly always to be. What the property is which changes the condition of certain substances will presently be noticed; what we are here concerned with is the popular idea of that property in bodies to which the term elastic is applied, and to show that while in the main correct, it is apt to be, and in many cases is, far from being so.

Elasticity.—Definition of the term, etc.

What, then, constitutes the property of elasticity? how is the term elastic to be defined? And here the youthful student in mechanics, while in no way surprised to be told that his own or the popular conception of elasticity is just as likely to be wrong as it is to be right, will doubtless be surprised to learn that amongst men of science, or those connected either with its practical adaptation to technical work or with its enunciation and explanation as teachers, disputes exist as to what elasticity is. If these are not characterised with that warmth of feeling and pungency of expression which sometimes distinguish scientific no less than political discussion, it may be said that certainly there is such a variety of opinions that the definition of the term elasticity given by one is not accepted by another. With this war of opinion, which at least in more than one case clusters round points of science of which no one positively knows anything, nor will probably ever know all things concerning them, there being points which are clearly beyond the reach of human ken, the reader will be apt to be a little discouraged, inasmuch as he may feel that it is not likely that he will be able to understand what elasticity is, if wiser heads and more experienced minds than his have failed to hit upon a definition which all can accept as correct or axiomatic. We shall, however, entertain the hope that, by taking or endeavouring to take what we may call a common-sense view of the subject, we may be able to give him a fair conception of what elasticity is, even in a strictly scientific, at least common-sense scientific sense. Moreover, the student may take this comforting assurance to heart: that if we cannot all agree as to what elasticity is, or what the condition of matter or the ultimate atoms of it in relation of this property, all can trace out and comprehend the phenomena dependent on, and so to say created by it, just as we can avail ourselves of all the phenomena of light, of heat, of weight or gravity, or of electricity, although men may never agree, as they will to all appearance never find out what they actually are. This, at all events, is an assuring fact, for the practical man who deals with "forces" makes and helps his "clients" or customers to make money out of them, although his own definition of what "force" is, or that of some scientific authority to "whose skirts he clings," may be disowned by some other authority as utterly intolerable if it be not pronounced as silly and absurd. The term "elasticity," then, has been defined to be that condition of matter in which the atoms are so placed or related only in one particular arrangement to each other that they yield to a force applied to them—that is, change their form so far; but which recover this form immediately on the force being withdrawn or ceasing to be exerted. In other words, the particles of an elastic body are driven inwards by—that is, yield or give way to—a force exterior to them, but on the force ceasing to exert itself, so to say, these particles are driven back again so as to resume precisely the same position they occupied before the force was applied. And this "something," which "drives," so to express it, the particles back again to their original form, is that to which the term "elastic" is given. For a body may have its atoms so arranged in relation to one another that a force external to them applied may drive them inwards, but they may remain in this position into which they are driven—that "something" being absent which drives them back again; and when this is absent we say that the body or substance is not elastic, or non-elastic, or inelastic. This use of the term "drive," while it gives a good idea of what is done by the external force and by that internal "something," may not be by many deemed to be scientific, or at all events elegant; yet nevertheless it is one which is derived from the very term "elastic" itself. For on examination we find that the word is derived from the Latin word *elasticus*, and this again from the Greek *elaunein*, which means "to drive"; and the common definition of the term elasticity, of which this is the root, is simply a statement of what we have already given—namely, that a body possesses this elasticity which when driven forward by a force can spring back when that force is removed,—or if its form be changed by the force, that the form will be resumed when that force ceases to be existent. We can now see the reason or root of the popular conception of an elastic body. Now, for the most part people associate the conception of non-elasticity, or want of "springiness" as many term it, with hard bodies, and of elasticity or springiness with bodies which are soft, but which when pressed with a force, say that of a grasping hand, or by the weight of a heavy body pressed upon them, are "put out of shape"—to use the common expression—or change their form, but which resume that shape or form when the pressure of the weight is removed or the grasp of the hand released. But if the soft body when pressed or grasped changes its form or shape, but does not resume this when the pressure is released, the popular mind at once decides that the body is not elastic. The difference between a ball of putty or of clay and one of india-rubber is at once distinctly understood, and this difference of condition thus experienced is expressed by the term elastic or non-elastic being applied. And it is just because this change of form caused by the driving back, and the resumption of that form by another driving back, as explained in preceding matter, is not made obvious to the senses, as in the case of soft yet elastic substances, that the popular mind generally has the notion that hard or very hard substances are not elastic; the chief exception to this being, as we have said, the case of a steel spring, which is so universally associated with elasticity that the term "springiness" has come to be more popularly and generally used as denoting this quality or property of elasticity than this latter term itself. This springiness or tendency to resume its preceding form or position when pressure is relieved from a body is indicated when we use the terms or words—

"Recoil,"—"Resilient,"—"Resiliency."

When we take an elastic body, as a ball of india-rubber, and throw it in a straight line against a wall, the ball comes back again towards us. In common language we say that the ball "springs" back from the wall, or leaps up or springs up from the floor or ground. In the more precise term of science, we say that the ball "recoils." To many, this word, taking it simply as it stands, conveys no definite meaning, or may convey an erroneous one, as involving the idea of twisting or coiling. The full meaning of the term, and the light it throws upon the phenomena of "repulsion" from elasticity, is perceived when we examine the root or source of the word. It is derived from the French verb *reculer*, and this from the Latin *re*, again, and *culus*, the back, or rather the posterior part of the body. Literally, then, it means "back again," "to come back," "to draw back," "to spring or leap back," meaning all the same thing as "recoil." The word "rebound" is synonymous with recoil, and is itself derived from the French verb *bondir*, to leap or spring back. The term "resilient" means in effect the same thing, but there is this difference. In the technical language of science we use the term "recoil" in connection with bodies in motion acting under forces; we employ the word "resilient" in connection with bodies at rest under the influence of force or pressure. The term "resilient" is derived directly from the Latin *resiliens*, which is the present participle of the verb *resilere*, to leap backward, and this from *re*, again, and *salere*, to leap. Thus, a wrought-iron beam, for example, which spans an opening, may in its normal or ordinary condition, when sustaining its own weight only, be level through its length, as at *a b c* in fig. 20 (see next chapter.) But if it be subject to a heavy weight, say of a passing railway train, it is bent or pressed downwards from the centre *e*, the lower side of the beam assuming a more or less decided curve, as at *d e f*. This bending or pressing downwards of a beam is called technically its "deflection," which denotes the effect of the pressure or strain to which it is subjected. This term, again, is derived directly from the Latin verb *deflectere*, and this latter from *de*, from, and *flectere*, to turn or bend. When the weight or pressure which is presumed to cause the bending or deflection, as illustrated at *d e f* in fig. 20, is removed, the beam has a tendency to return to its normal or level condition, as at *a b c*. This is literally a springing back from position *e* to position *b*, and the tendency is called the "resiliency" of the beam. What in beam work is called technically "camber" is giving to the form as at first made a curve or set in a direction opposite to that at *d e f*, as shown at *g h i*, the object being that when the beam is placed *in situ* or permanent place or position it will, from the pressure or strain produced from its own weight, or that put upon it, fall down, as it were, in the centre *h*, and assume the level line, as *a b c*. So closely do engineers calculate the dimensions of a beam, of whatever form of construction, solid or open or lattice girders, that they can give to it such a precise amount of "camber," as at *h*, that on being placed *in situ* they know that it will assume the line they desire it should have. Just as, on the other hand, they can calculate, when the beam is subjected to the pressure or strain to meet which it is designed, what the precise amount of "deflection" of the beam, as at *e*, will be, and that when the pressure is taken off it will assume the form of *a b c*, or that which it is designed to assume.

Peculiarities in Bodies or Phenomena dependent upon the Elasticity of Matter applicable to Mechanical Practice.

The young mechanical student should now have a fair conception of what that property of bodies is to which the term elasticity is given, and this without going at all deeply into the abstruse disquisitions so delighted in by some writers as to what elasticity is. Neither will it serve any great useful or practical purpose, when at this stage of his technical education, to follow some of those writers into the details of what we presume must or ought to be termed investigations into the condition of the ultimate atoms of matter. He may therefore, with all safety—and indeed by doing so secure the safety which will be of practical value to him—assume that there are no bodies, or there is no body, absolutely that is perfectly elastic, any more than there are bodies or a body absolutely and perfectly non-elastic. And this he may do in the face of the assertion of some of those who have made the investigations above alluded to, that the ultimate atoms of matter are "absolutely non-elastic or inelastic." All assertions of this kind are based upon mere assumption; they cannot possibly be based upon facts which are known. The ultimate atoms of all matter are so minute,—or let us put it in this way, are said to be so minute, that they are further stated to be absolutely invisible—that is, they are not capable of being split or cut up, so to say, into two or more parts, the atoms being the final condition in which matter exists, beyond which it cannot possibly go. Again, it may well be asked, If atoms are invisible, how can you see to cut them up—if a thing which is indivisible can be cut up? If atoms be inelastic absolutely, the young student will have what he may justly call a common-sense difficulty to see how a body —which is assuredly made up of the atoms, otherwise it cannot exist—can become elastic, when the very things (if we may by this undignified term denote the highly scientific term atoms) of which the body is composed are themselves inelastic. He might ask a very familiar, or what some might call, in view of the dignity of science, a vulgar question, such as this: "If you have a heap of coins consisting of what you call sixpences, how is it that you say that they are changed into shillings? or, if so, how does the change come about?" Or this: "You have a heap of bricks, each brick being neither more nor less than a brick, and when built up you form what is—a brick wall?—no! you say it is a stone wall, or a wall of some substance or another, but not brick, for the bricks are changed: how, then, does the change come about?" But then, in regard to this assertion that the ultimate atoms are "absolutely inelastic," the difficulty in connection with the theory upon which the phenomena of bodies in a gaseous or aeriform condition are accounted for on the supposition that atoms *are* elastic comes into existence. And some very easily meet it by asserting that there are different kinds of atoms, or, as we should perhaps rather put it, different conditions of the ultimate atoms, one condition giving the property of elasticity, which, as we have seen, they do not grant to the ultimate atom itself. But they do not know how this condition or change is brought about.

Elastic and Non-elastic Bodies.

We have seen, in noticing the phenomena of "attraction and repulsion" of moving bodies, that action and reaction are equal and opposite; and we have shown this by various illustrations drawn from circumstances of daily life. The law of action and reaction equal and opposite, which is of the utmost value in mechanical work, is further illustrated by the phenomena of *elastic* bodies in motion. If a *hard* body strikes a soft and yielding body, the softer body gives way, receding from the harder body in virtue of the principle or law of impenetrability which forbids any two bodies to exist in the same space—the result being that the shape or form of the soft body is altered, and a permanent malformation or deformation is the result. It is in the capability to receive a permanent deformation that, in the popular sense at least, lies the evidence that no body or substance is non-elastic. As we have seen that no body is absolutely non-elastic—at least, that it is exceedingly probable that this is so—the soft body will present some degree of resistance, so to call it, to the influence of the hard body to cause a change in its shape. And just as the body increases in elasticity, so does its power to resist permanent alteration in its form increase; till when two bodies equally elastic come into forcible contact with each other, the force of the concussion causes no permanent deformation or any visible alteration either in their general form or at the point where they come in contact with each other. We say no permanent deformation, no visible alteration in the concussing or colliding bodies, which we of course assume to be perfectly elastic—using the term perfectly in the conventional sense, as no other is open to use. Thus we call all gases or airs perfectly elastic, liquids in this sense the same; the difference between them (as air and water, for example) being that the range of elasticity or extent through which it is exerted is very large in the case of the air, and so small in the case of the water that it is practically inexpressible. Steel and ivory we class as perfectly elastic bodies; so also glass under certain conditions, which overcome another property it possesses of being in certain other conditions very brittle. All these are held to be perfectly elastic, as they will not retain permanently any bend or change of form given to them. Thus india-rubber, which some hold to be a perfectly elastic substance, and is beyond all doubt one of the most elastic substances we possess, is not perfectly elastic, because there is a condition in the change of its form in which it will retain that form.

Elastic Bodies—Action and Reaction.

This property of perfectly elastic bodies to retain no deformation, or—to use a term familiar to all mechanics—to keep no "set" which may be given to them by the application of a force superior to their power to resist it, or in other words sufficient to overcome their elastic strength, must be borne in mind in considering generally the phenomena of elasticity in bodies in motion or subjected to "force" or "pressure." But while we see that there is a permanent change of form, it must not be concluded that there is no change in the position of the particles of the body perfectly elastic or considered to be so. In the case of two ivory balls coming forcibly into contact by forces acting in opposite directions—the force being equal and the masses also—there is in reality a compression of the particles nearest the point of contact, so that a flattening of the surfaces of each takes place, and of equal extent. But that there is a flattening or change may be proved by dashing the ivory ball with great force against a marble slab, the surface of which is wetted or visibly moist: the water or moisture will be found to have been dried up or to have disappeared over the same extent of circular space which is the measure of the flattening out of the surface of the ivory ball at the point or part of its contact with the slab. This case is an example of the "retarded". motion caused by the force of "repulsion."

THE YOUNG ARCHITECT OR ENGINEER.

HIS STUDIES—OFFICE DUTIES—AND PRACTICAL WORK IN THE PREPARATION OF WORKING DRAWINGS, OF SPECIFICATIONS, AND CONTRACTS FOR WORK.

CHAPTER XII.

Chimney-pieces.

Window sills.

AT the close of last chapter we partly specified the Mason's Work. In continuation of this we now proceed. A [name the kind or class and quality of stone to be used] stone chimneypiece to be provided and fixed in kitchen, with 12-in. jambs and mantel, and 9-in. shelf. The chimneypiece in drawing-room to be of marble, of the value of £ ; that in parlour to be enamelled slate, of the value of £ . The chimneypieces in bedrooms of stone, 7-in. jambs, and moulded trusses and plinths; stone "rebated," "weathered" and "throated sills" (see "The Stone Mason") to be placed to all window openings, 12 in. wide, 4½ in. at heel, and 3 in. at nose, firmly bedded in mortar. Fit up larder with two tiers of 1-in. planed slate shelves on iron brackets (the brackets to be provided by the blacksmith).

CARPENTER'S WORK.

Quality of timber.

All the timber to be used in the building to be of the best description throughout, free from all sap, shakes, large or dead knots, and all other defects.

Scantlings of roof timbers.

Bay windows.

Eaves.

The pine or fir timber shall be of the best yellow "Dantzic," "Memel," or "Riga" timber, the deal shall be of the best Petersburgh, and the oak used to be of English growth. The contractor to provide, fix, and strike all centering. Pine or fir lintels of the width of the brickwork, 3 in. thick, and having a bearing of 9 in. on each side, to be placed over all openings. The roof truss to be of the form and to be framed together as shown on section and plans; the rafters to be 4 × 2½ in., securely spiked to 9 × 2 in. ridges and hips. The wall plates to be 4 × 3 in., and the rafters where shown to project 2 ft. from wall. The ceiling joists to be 4 × 2½ in., bearing on the wall plates, and securely nailed, supported by a piece of timber 9 × 6 in. The space between rafters and ceiling joists not to exceed a distance of 14 in. from centre to centre. The bay windows in front elevation 3 × 2 in. on plates 3 × 2 in.; the ceiling joists to be 4 × 3 in. on wall plates 3 × 2 in., and to project from face of wall as shown in drawings. Six-inch wrought and beaded facia boards to be fixed to all eaves where shown. All timber used in the construction of the roof to be of the best description of fir as specified, and all portions of roof that project to be wrought.

Scantlings of timbers on ground floor.

Timber of drawing-room, etc.

The joists on ground floor are to be of fir 4½ × 2½ in. on plates 4 × 3 in.; those on first floor to be also of fir, 10 × 2½ in., nailed to plates 4 × 3 in., and strutted or strained with a row of herring-boned struts, 2 × 1½ in., wherever the bearing is more than 9 ft. Lay the floors of drawing-room, breakfast-room, parlour, lobby, kitchen, and china pantry, with 1¼-in. deal battens, properly nailed to joists, and finished with mitre strips round hearthstones. Inch deal floors to be laid on first floor of joists, made good round hearthstones as before, and nailed with 2-in. brads.

THE JOINER'S WORK.

Doors on ground floor.

The doors to drawing-room, parlour, and water-closets, to be 2 in. thick, six-panelled, double moulded, and hung with 3-in. butts to 1½-in. double rebated jamb linings, with 6-in. moulded, beaded and sunk architraves round same. A 2-in. sash door to be hung in lobby, with 3-in. butts, double moulded panels, jamb linings, and architraves as above specified. The remaining internal doors on ground floor to be 1½ in. thick, four-panelled, square framed, and hung with 3-in. butts to double rebated jamb linings, with 3-in. band moulding on same.

Front or entrance door.

Back garden door.

Doors on first floor.

The front door to be 2½ in. thick, two-panelled, moulded one side, bead and flush on other, and hung with 4-in. butts to 4 × 3 in. wrought, rebated and beaded frame, with head over to receive sash and transom 4 × 3 in. The back garden door to be 2 in. thick, four-panelled, bead and flush, hung with 4-in. butts to 4 × 3 in. wrought, rebated and beaded frame, and 2-in. oak moulded step and riser. The doors on first floor to be 2½ in. thick, four-panelled, double moulded, and hung with 3-in. butts to single rebated jamb linings, and 3-in. band moulding run round them; the door leading to balcony to be hung to 4 × 3 in. wrought, rebated and beaded frame, with 3-in. butts.

Windows.

Drawing-room and breakfast-room windows.

The windows to have 1½-in. deal ovolo or lamb's-tongue sashes, double hung and fitted in frames, the pulley stiles to be 1¼ in. thick, with ¾-in. beaded linings, and ⅜-in. parting beads, oak sunk sills, with all necessary weights, lines, etc. A fixed sash in 6 × ¼ in. frame to be placed in partition between larder and china pantry. The drawing-room and breakfast-room or parlour to have 1-in. grounds properly boxed and fixed round windows, with 6-in. moulded and sunk architraves on the same, to correspond with that round door; 1¼-in. splay, one-panelled, soffits moulded; 1¼-in. panelled and moulded backs and elbows, with all necessary cappings; 1¼-in. four-panelled moulded shutters, and 1-in. square four-panelled back flaps, the front shutters to be hung with 3-in. iron butt hinges to window frame, and the back flaps with 2-in. flap hinges.

Kitchen and scullery windows.

The windows of kitchen and scullery to have 6-in. plain architraves and plain soffits on proper grounds, with 1¼ in. two-panelled shutters on splay, hung to splay with 3-in. butts, and 1-in. square-panelled back flaps, hung with 2-in. flap hinges.

Windows on first or bed-room floor.

The window openings on first or bedroom floor to be filled in with sashes and frames, as specified before for ground floor.

A dresser with five drawers and cupboards under, with square framed doors, to be fitted up in china pantry, with all necessary shelves, supports, hooks, etc.

Kitchen, lobby and water-closet fittings.

The dresser in kitchen to be 9 ft. long, with drawers and cupboards under, and shelves above, with turned supports and brass hooks. Provide and fix a mahogany hat-rail, 4 ft. long, with brass pins, in lobby, as may be shown. Provide a 1½-in. strongly made cover, with handle, to copper in scullery. Provide and fit up water-closet with inch panelled and moulded back and elbows, and riser, with ¾-in. clamped mahogany lifting top, nosed on front, and hung with brass butts. A 1¼-in. red deal seat with turned cover complete. Provide and fix a 1½-in. wood cistern, 4 ft. long, 3 ft. wide, and 2 ft. deep, dovetailed and tongued, over water-closet, on proper bearers.

Staircase.

The staircase to be carried by strong carriage pieces 4 × 4 in.; 1¼-in. deal moulded and nosed steps and landers, and 1-in. risers, tongued and glued together with wood blocks. Returned "nosings" to be given to all steps, and cut brackets on outside string, as per detailed drawings; 1¼-in. moulded wall string, and 1¼-in. moulded, sunk and beaded outside string, properly tenoned into all newel posts.

Hand-rail of staircase.

A mahogany moulded hand-rail, 3 × 2 in., to be fitted to stairs, with turned scroll on iron newel post, with all necessary nuts and screws; 1¾ in. red deal balusters over stairs.

Kitchen staircase.

The kitchen stairs to be constructed on strong carriage pieces, with 1-in. deal nosed steps and risers glued and blocked together, 1¼-in. wall and outside strings with all newels; and to be finished with a 1½ × 2½ in. oak hand-rail, and 1-in. deal square balusters.

Cellar doors and fittings.

The doors of wine and coal cellars to be 1 in., ledged, and nailed with wrought nails, hung to wrought and rebated frames 4 × 3 in. by 3 in. iron butts. The windows to have solid 4 × 3 in. frames, with iron bars fixed in same. Fit up wine cellar with 1¼-in. shelves and bins, and 3 × 2 in. uprights, and all necessary divisions.

PLASTERER'S WORK.

The whole of the internal plastering is to be executed in mortar composed of well burnt chalk lime thoroughly incorporated with clean sharp river sand and good hair, mixed in proper proportions.

Mortar to be used for plaster.

The whole of walls and lathed partitions to be rendered, floated and set

Plastering work.

Lath, plaster, float, and set all ceilings and staircase white in putty, cut quirks to all angle beads, etc. The laths to be of the best description of Baltic, free from sap, butted not lapped, and nailed with cut nails.

Laths.

Run a cornice of 12-in. girth or depth to drawing-room, with three enrichments, and fix a centrepiece in ceiling of 3 ft. diameter, a 9-in. girth cornice to be run in parlour or breakfast-room and lobby with two enrichments, and centrepiece 2 ft. in diameter fixed; 8-in. cornices to be run in bedrooms, with all necessary internal and external mitres.

Cornices. in drawing-room, breakfast-room and lobby.

Run 14-in. moulded skirting in Keene's patent cement to drawing-room and parlour, a 10-in. skirting in china pantry, water-closet, and hall, to correspond with string of stair, those in bedrooms to be 8 in. high, the whole to be executed according to drawings provided; plain skirtings in cement 6 in. high to kitchen and scullery. All jambs and heads to windows, strings and plinth courses, with all mouldings, trusses, etc., to be run where shown on drawings, and in detailed drawings.

SLATER'S WORK.

The roof to be covered with best "Duchess" slates, properly squared, 12 × 24 in., laid with a 3-in. bond on battens 2 × ¾ in., nailed with two good zinc nails in each slate, the eaves to be doubled in every part. The ridges are to be covered with slate roll and crease, (2-in. roll and 6 in. crease) properly nailed and riveted. The whole to be left in a perfect state at the completion of the works.

THE PAINTER'S WORK.

Knot stop and paint the whole of the wood-work and iron-work usually painted, inside and outside of building, four times, in good-bodied white lead and oil, plain colours as may be directed. Grain the whole of the wood-work in drawing room, parlour, hall and lobby, water-closet, the wall and outside strings of staircase, and exterior of front and back doors, in such imitations as may be selected, and twice varnish the same with best copal varnish. The wood-work of kitchen and scullery to be finished in wash oak, and the grates and hearthstones throughout the house to have two coats of black paint. The whole of the glass used to be of the best description, free from all defects. Glaze the sashes of drawing-room and parlour with plate glass ⅛ in. thick, securely sprigged and puttied into frame. The remaining sashes throughout the building to be glazed with crown glass, except the sash door in lobby, window in hall, and fanlight over front door, which are to be filled in with diaper and ruby glass.

SMITH'S WORK.

Provide a kitchen range of the value of £ ; a 10-gallon cast-iron boiler with fire bars, etc., complete; and iron gratings for sink trough and where otherwise shown. The drawing-room to be fitted with a bright steel register grate of the value of £ , and the parlour with register of the value of £ ; the three bedrooms to have 36-in. sham register grates of the value of each; the whole of the grates to be selected. Provide and fix 4-in. cast-iron ogee shuting to all eaves, with all necessary 3-in. down pipes, heads, elbows, and hooks; supply ¾-in. wrought-iron bars for windows of cellar, larder, water-closet, and lobby, perforated zinc to larder window; provide cast-iron coal plate, with all necessary chains, staples, etc., and a cast-iron scraper to steps, also iron brackets to receive larder shelves.

The bells are to be hung on the best principle, with all necessary wires, cranks, pulls, etc, etc. The drawing-room and parlour to have two enamelled-faced levers in each room, to ring one bell each. No. 1 pull to be fixed in hall to ring call bell on chamber floor; six cranks to be fixed on chamber floor to ring three bells on ground floor; also one pull and out-pull to be fixed to entrance door to ring bell on ground floor. All the bells to have pendulums, and the whole to be left in a complete and perfect state.

PLUMBER'S WORK.

The water-closets to be fitted up with the best pan closets and blue-ware basins, on the best principle, with 4½-in. soil pipe, of 7 lb. lead to the foot superficial, with copper wire, and lead service pipe from cistern, which is to be lined with 5 lb. lead, and provided with 1½-in. overflow pipe. Provide and fix a 3½-in. force pump in scullery, with 2-in. suction pipe from rain-water cistern, and a 1½-in. supply pipe to cistern over water-closet. Lay the balcony over water-closet with lead of 5 lb. to the foot superficial, also all gutters, flushings, valleys, etc.

THE WORKMAN AS A TECHNICAL STUDENT.

How to Study and What to Study.

CHAPTER IX.

Referring to the question stated at the end of the preceding chapter, we say, that important as the maintenance of this supremacy would be, in view only of the chances of its being likely to be contested by the peoples of other countries, its permanent importance is most conclusively, and to us as a people somewhat painfully proved, by the fact that in some departments of trade and manufacture we have actually already lost some of that supremacy; and in others it is being daily, and to a large extent successfully, maintained by countries chiefly Continental. This position, then, is not what years ago it was—namely, the possibility of our "making" our supremacy disputed—but is that it is actually disputed; and hence the anxiety it is causing amongst the best men of the day, who are impressed with the vital importance of the position, and with the idea that something must be done to meet it.

Practical Difficulty in adapting Systematic Technical Education to Working Men as a Class, who have Long Hours of fatiguing Work, Short Hours of Leisure, and live in Widespread Localities.

We have just said that the practical difficulty in placing within the reach of the class who really constitute the workers of the country that technical education they require, and which their position as workers demands, arises from the position they occupy considered as communities of workers. We have shown the two peculiarities of this position. And but a trifling degree of consideration will show that, whichever of the two be taken into account, it is extremely difficult to place before these communities those facilities which we have shown to be necessary to make technical education practically valuable. Where the population is dense, the area of ground occupied by them is very large, and this even although too many, far too many families—that is, houses—are crowded into a space all too confined and small for the maintenance of good and regular health. Now, the larger the district, the greater the distance of one locality from another, and the greater, as a necessary consequence, the time occupied in traversing that distance. If, then, only one large technical school or college be given, say to one town, no matter how judiciously its site may be chosen, it may be taken as incontrovertible that that site will not meet the whole necessities of the case. Although placed, for example, in the locality where the population is densest, and therefore affording the best chance of drawing to it the largest number of "pupils"—to use the ordinary term, although working men have a great objection to be ranked and named as such, even the other term, "scholars," being to many amongst them not associated in their minds with what is dignified as grown-up men or lads—it is but too readily forgotten that it is a great demand to make upon a working man, after having had a hard and fatiguing day's work, that he should add to this fatigue by trudging a mile or two, or perhaps more, to the technical school or college. The mere time, again, he has at command to do this makes the difficulty all the greater; for, short as working days are as compared with those which were the rule not many years ago, they are yet so long that, when finished, not many hours are left in which the limbs can be used or the brain work. Nor is this difficulty of locality of the technical schools lessened in districts where the technical workers are more thinly congregated, or in districts which might almost be termed rural, where the workers are pretty well isolated as communities. It may, indeed, be said that the difficulties are greater.

Much may be said on this point, which, whatever some may think of it, is in reality the crucial one, and which will dictate the failure or success of the schemes for technical education now being so much talked about, and, in many districts, about to be so well organised. But enough has been said to show that it will have to be fairly met if the good work to be done is in reality secured. The only way out of the difficulty is so to multiply technical schools or colleges that each town or district will be supplied in strict proportion to its population requirements. And this simply means enormous expense, the country being considered as a whole. And the question now for the nation to decide is, whether it will be wiser, and in the long run cheaper, to go to this expense now, or to fritter valuable years away in only doing the work in a half-hearted, indeed, we might say, wholly indifferent way. The nation must decide, and that quickly, whether it is more important to save this money in the meantime, or ultimately to lose, or largely lose, the "trade" by which that money is almost wholly made. That the expense of this, meeting the actual necessities of the case, will be enormous, taking the various districts of the country all round, is clear enough. For it must be recollected that it is much cheaper to concentrate in one place all the facilities for technical education than to spread these facilities over a number of places. Not only must the appliances and such motive power as they require be repeated, but the staffs of teachers also; and this, to say nothing of the buildings, tells very powerfully in the way of expenditure. For to make the technical education what it ought to be, and must be if it be given at all, everything must be of the precisely superior order required. The staff, for example, must be equally efficient in all the schools or colleges established, for it will be in every way penny-wise and very pound-foolish to save money in this, or indeed in any other direction, merely for the sake of saving; that is, making the "bill of costs" less in amount.

Now, much as has of late years been said—and although more has been said of late years than ever before—we confess to seeing no signs that the nation is prepared to go into this large expenditure; and this for the all-sufficient reason that the national mind, as such, is not yet impressed with the idea that it *is* a matter of vital importance that technical education be given to the workers of the country. The national mind may, it is true, be thoroughly impressed with the idea that it is vitally important that we should not lose our trade, and be agreed upon this; but the national mind is not yet convinced that technical education will be the means of preventing this loss. Nationally, indeed, it may be said with all truth that we are yet in a condition of profound indifference as to the question. Even if all were done which is being talked of, it would be as it were but a mere drop in the bucket, compared to that which must be done if true efficiency be desired.

The Problem of a generally extended Public System of Technical Education, embracing the Working Classes as a Community, yet to be solved.—What can be done by the Individual Workman Student, in acquiring Technical Knowledge.

Practically, therefore, the question how best to give our workers that technical education which the best men amongst us know to be essential, and are so desirous to give, is yet to be solved; and its solution will test the ability of the best amongst us, and test also the reality of the interest which so many profess to have in it, as to what they not only wish to be done, but are ready, as they say, to do. Time alone can put this to the test; meanwhile, as the steed may starve while the grass grows, not a few amongst us are trying to do as much as can be done with the facilities at present at command. Hence, amongst other directions, they turn to the present schools, and the systems of education, in the hope that something may be done by their agency. We have pointed out one way in which they will have to be modified before they can become useful. But at the best, so far as is seen at present, they are only or chiefly calculated to operate with the youth of the country, and do not touch, or are not likely to touch, the grown-up workers amongst us. This question, therefore, comes up for answer, and that in a thoroughly forcible way: Can those grown-up men not have the necessary technical education, if in some simpler way than by elaborately organised technical colleges and institutes—which as yet do not exist in the extended way required, and if they existed, could or would not by many be made practically available? We are of those who think that such means are within the reach of our grown-up workers, which, if not possessing all the efficiency of well appointed colleges or schools, do possess the capability of being largely useful. We need scarcely say, after all we have given, and also indicated, if but briefly so, in the title to our paper, that this method is within the reach of all, for it is based on the principle of self-help, or personal study. And the very object of this work, and the presiding cause of its existence, is to help the students in this great work of self-help, in the way of acquiring technical education. It is not necessary to state here how this is to be done. The several chapters of each specific subject will be the best exponent of the methods by which we hope to give this help to our readers. Sufficient is it for us to say that no efforts will be spared by the various writers to make their expositions as practically valuable as possible. Each will bring to his subject all the value which experience of its details enables him to impart to his readers; and each will be abundantly repaid for his labours if they are able, even in but small degree, to share his experience with him.

Advantages of Technical Study to the Working Man, not only in Increasing the Chances of his Success in Life, but in Strengthening the Mental and Moral Faculties.

In the preceding paragraph we brought our introductory remarks up to that point at which we showed that in the present condition of technical education—and what, to judge from facts around us, seems likely to be that of a long time to come—much depends upon the workman himself as to how he is to obtain the advantages which that education is so well calculated to give him. We have shown also in a general way how those advantages bear closely on his progress in his working life, and how they give him a power which, wisely exercised, is of the utmost value to make that progress, humanly speaking, certain. We have shown, at all events, that if the possession of those advantages may not always secure great success in working life, success cannot possibly be obtained without them. This alone is a consideration calculated to urge the prudent man to endeavour to make those advantages his own; for it is ever the aim of a man of this condition to try and avail himself of any chance of success in life—to convert what *may* be a potent power in securing this into the *must* which makes success certain. But apart from the practical progress in working life which the attainment of knowledge bearing upon it is so well calculated to help forward, it carries with it a power for good which no wise man will overlook or undervalue. It strengthens the mental and moral faculties alike certainly and powerfully; it creates and promotes a desire for ennobling pursuits, as in direct and immediate consequence it urges him to flee from and to warmly dislike all those which tend to lower and degrade him both physically and mentally. The mere desire to acquire useful knowledge, and the determination that he will if possible have it as his very own, tends to make him respect himself; and self-respect is too valuable a factor in the sum which makes up the comfort and happiness, not only of the individual, but of all those with whom he is associated or comes in contact, to be other than highly valued.

The direct bearing which useful knowledge has upon a man's success in working life we have in brief terms glanced at; it will be further illustrated and enforced by those incidental circumstances which will come up as we discuss the various points of the important subject which forms that of the next half-dozen paragraphs or so. It will still more clearly be shown in the course of the later paragraphs treating of the various special subjects which make up the bulk of our series of papers under the present title. We are now prepared to take up the points waiting for consideration.

For reasons which will become obvious as we proceed, we reverse the order which might have been given, in which the subjects of study preceded the way in which the study should be carried on, and glance first at the how, thereafter taking up the what to study.

Some Points connected with Education.—Its General Definition and Practical Characteristics.

And here, at the outset, we again draw attention to what is but too frequently and persistently overlooked by many—namely, that education is something more than the mere presentation to the student of a number of subjects, the nature and the facts connected with which he is expected by some process or another to understand and recollect; the committing to memory certain things being, in this false system of education, considered of vastly greater importance than the understanding of them. When education is so conducted, it is not to be wondered at that the expectation that it will be of practical value in life is so seldom realised. A man can scarcely, at least with reason, be said to be fed who has merely been supplied with food; neither, indeed, should he actually even have partaken of it if it be not healthily assimilated by the system. It is very easy to select a number of subjects for the student,—it is, so far as it goes, as easy as merely naming them. And in but little more than the doing of this some teachers and students seem to consider that all teaching consists. It would have been well to-day for the prospects of technical education had they as a rule grasped the full intent and meaning of what education really is. It is the capability in the student to take up facts, and to have them, so to say, digested and assimilated, by thoroughly understanding them.

THE GRAZIER AND CATTLE BREEDER AND FEEDER.

THE TECHNICAL POINTS CONNECTED WITH THE VARIETIES OR BREEDS OF CATTLE—THEIR BREEDING, REARING, FEEDING, AND GENERAL MANAGEMENT FOR THE PRODUCTION OF BUTCHERS' MEAT AND OF DAIRY PRODUCE.

CHAPTER XIX.

State or Condition of Food.—Cooking.—The Kind of Animal fed, or Modifying Principle in Food.

THE importance of state or condition in which the food is given to the animals is also illustrated by the practice of "cooking," which obtains so widely amongst practical feeders, that special apparatus for the purpose forms a part of the mechanical fittings of every well-regulated farm where feeding of stock is part of the work. Much the same effect, doubtless, is secured by cooking food for animals as results from this method of preparing it for man. It is made more readily digestible and assimilated by the animal—it makes the true flavour of the food more decided, or imparts to it one which does not exist, or is thoroughly latent, in its uncooked state. Possibly the best result of cooking is obtained for animals by its effect on the woody fibre existing in all plants. When this is soft and yielding it is most easily digested and assimilated, but when hard, as in the case of dead-ripe and sun-dried grains, such as oats, they pass through the animal in greater or less numbers without being acted on at all by the digestive juices or liquids of the system, and are passed from the animal in their ordinary perfect form. To bring hard woody fibre to the soft condition in which it can be readily acted upon and assimilated by the system, cooking is of great service, independently of such other results as may be secured by it, and to which we have already alluded. But here, as in every other department of feeding, circumstances modify greatly the normal or ordinary results of the system; so that the patient observation and careful attention of the feeder will be required to be given in order to discover what those modifying circumstances are, and how far the stock which he feeds is influenced by them. The kind of animal presents one of those modifying circumstances. Thus, all ruminating animals—that is, those which chew the cud, as the cow—are least likely to be benefited by having their food cooked, or at least by having much of it thus treated; and this from the circumstance that the food, after being passed into the stomach and there acted upon by the digestive fluids, is again returned from it, and subjected to the ruminating process, which has the effect, so to say, of triturating it; so that the woody fibre will be further softened. In view of this some feeders object altogether to the cooking of food for cows—as it tends, or as they think it tends, to do largely away with the necessity for the animal to chew the cud—and which interruption to a natural process, designed for wise ends, they conceive likely to be prejudicial to the health of the animal. We note this point not merely because it is one in the practice of some feeders, but as it will show the youthful student of agriculture how necessary it is that he should closely observe the habits of animals, and study all the peculiarities, not only of each class of animals, but if he be a prudent feeder, the individual peculiarities of each, so far as he possibly can. It was by knowing all about *individual* animals, so far as they could be known, that our first and most eminent breeders succeeded in establishing their celebrated "breeds."

Methods—other than Cooking—of preparing Cattle Food.

Closely connected with the effects of cooking the food upon the animals fed upon it are those of certain other methods of treating food, such as that adopted with marked success by some feeders. The feature of this method consists in the cutting up of forage foods, such as the grasses, Italian rye grass, lucerne, etc., in their green state, mixing the cut produce with straw chaff or cut straw—pressing the mixture together, and keeping it stored up either in a corner of the building or in large bins provided for the purpose. Food thus prepared keeps good for a long time, and undergoes a certain kind of fermentation, which imparts a flavour to it which makes it specially liked by stock. This method of making a combined food of green produce and dry straw may be looked upon as a modification of or a substitute for what is called the new process of ensilage, but which is anything but new—being in fact the revival of a very old process—at least as old as the time of the Romans. And we are inclined to think that much of the benefits said to be gained by this method of storing up forage in its green condition arises from the flavour or certain peculiarities imparted to it by a species of fermentation set up during the period in which it is stored up in the tanks or receptacles made to receive it. Food not cooked or previously prepared, and stored away, not used at the time of preparation, does undergo a process of change—one of the results most usually obtained being a certain degree of sourness or acidity. Now, those new to the subject would be apt to suppose that this sourness would not only be prejudicial to the animals, but would be greatly disliked by them. But those who have closely observed their habits, and noted with care the effects of different kinds of food upon them, must have observed how fond most animals are of food a little—not too much—sour, and that they thrive well upon it.

Flavouring of Feeding Stuffs for Farm Live Stock.—Condimental Foods.

The effect of certain flavours in modifying the nutritive value of foods for the live stock of the farm, and, as a rule, when judiciously employed, greatly increasing their value, by causing them to be more quickly and completely assimilated by the animals, is now well known. It is to observation of this peculiarity that we owe the feeding substances known by various names, but which are generally or popularly called by the generic name of "cattle foods." This, however, is by no means specific enough—for all farm feeding substances are cattle foods—the term "concentrated" or "condimental" has therefore been applied to designate the special kinds of food here alluded to. And, of these two, the last gives the more accurate conception of their character; for they are, in great measure, made up of substances which give a certain flavour or taste to the composition considered as a whole—some of these substances being purely condimental, as much so as mustard or pepper taken by man with his food. But in addition to merely flavouring substances, these "cattle foods" contain, as a rule, others which, while designed also more or less directly to affect the taste, have for their special object an influence of a medicinal character, so as to favourably affect the health of the animal. Of these condimental or concentrated cattle foods, that of Thorley may be taken as representative, if only from the fact that he was first in the market with a food of this kind, and which by continued and most extensive advertising he made for years notorious everywhere. Much has been written and said in connection with these foods, both against and in favour of their use. The unfavourable opinions have generally emanated from scientific authorities; the favourable from those who have been engaged in the practical work of feeding as a trade by which they lived. And this suggestive fact, coupled with this other—that their use amongst practical men is very extended, and is beyond all doubt increasing—is some proof that practical men have found that they were good for their stock. And it is further to be observed, in this connection, that those who have written against the use of such foods have confined themselves almost wholly—some, indeed, exclusively—to warning farmers against their use simply because the price charged for them by their makers was out of all proportion to the real value of the materials employed in their manufacture. Some of these are, no doubt, costly enough; but the "base" or great bulk of the food is made up of such commonly met with and comparatively cheap food—such as wheat, meal, Indian corn, and the like—that the charge of excessive price brought against these foods was well justified. But the youngest or least inexperienced of our readers will at once perceive that, however clearly it may be established that the price or cost of any article is greatly in excess of what may be called its legitimate cost, or the price of the substances of which it is made, this constitutes no argument of any worth whatever against the use of the article as a food. It may be both dear and bad, but it may also be very good although it be very dear. It is, at all events, most suggestive that the arguments brought forward by some against the use of these condimental foods have chiefly centred round the point of cost, few attempts having been made, either by absolute trial or by scientific deduction, to show that their use was prejudicial, or, if not positively so, at least not worth paying any price for.

Condimental Foods for Farm Live Stock (*continued*).

Nor need this be matter of surprise, for it would have been difficult to decide definitely against them as being useless, in face of the fact of their most extensive employment by practical feeders of cattle, some of them being of the highest eminence. Still more difficult to maintain this position in face of certain physiological facts, and of analogies which can be reasonably and justifiably drawn from what we know of the effects of certain foods and methods of preparing foods used by man. And beyond all doubt nothing would more tend to the wide and rapid introduction of a rational and therefore economical system of stock feeding than an appreciation of the truth that the facts and principles which affect the habits of man in relation to his food and physical health are of as great value in proportion when applied to animals. This truth is known and acted upon by our most distinguished feeders of farm stock, and is one of the many reasons why they are so successful both in their breeding and rearing; and the more closely the habits of our domestic animals are observed, the more will it be made clear that there are far more points of similarity between them and those of man than is generally admitted. So closely do many habits agree in both classes of the mammalia—men and animals—that they are suggestive of considerations almost ludicrous or grotesque in character. And, as we have said, it is upon such observations that condimental cattle foods are based, and their use so earnestly advocated by many eminent feeders. The greater the relish with which our fattening stock eat their food the more readily will it be assimilated; and it is in giving this relish that such foods are valuable. The writer of these pages has had opportunities given but to few of studying the whole subject of cattle feeding and foods, and of practically testing a very wide variety of them. This also applies to condimental foods; and a very extensive employment of them over a wide range of domestic animals has fully convinced him of their great practical value when judiciously used. Here, again, the feeder must judge for himself; and a wise judgment can only be secured by a careful observation and a close study of the animals under his care, and of the foods he employs to feed and fatten them. While freely availing himself of the experience of others, he must not content himself alone with what this teaches, but he must study and observe for himself. And as regards the question of price or cost of such foods—or relishes, if the term be preferred, for in using them they only serve as supplements to, not substitutes for ordinary foods—the point is very easily described. If he objects to the price charged by makers of these special foods, it will take no great amount of knowledge of the characteristics of various substances to enable him to concoct, so to say, a special food of his own. If to decide on the nature of this he has to make experiments with stock, he will not have any occasion to regret making them; for he will, if he closely observes and notes facts, learn much that will be of wider value to him than merely the finding out of a good condimental food or cattle relish.

Effects of the System of Changing the Kinds of Food given to Cattle upon the Economical and Effective Feeding.

Amongst other points he will probably see exemplified another circumstance which goes largely to modify the scientific or analytical value of cattle food. This is the effect of "change of food," and is obviously cognate to the last-mentioned subject of the "relish" with which cattle partake of their food. Here, again, analogies drawn from our own habits are of great practical value to the cattle feeder. The beneficial effect of change on the kind and quality of the food we ourselves partake of is so well known that it seems strange that the principle which it involves should have been, or more correctly stated, should be, so completely overlooked by many feeders of farm stock. This arises, no doubt, from the fact being so little understood that between our own habits and those of the animals we feed there are many points of similarity. No one who has closely observed the ways and doings of domestic animals but must have been struck with them; and in how many things they do just as under the circumstances we should have ourselves done. It is only the superior men—men of education, but above all possessed of habits of close observation—who have applied this knowledge of the habits of animals to their breeding and rearing, and it is in this way chiefly that our best breeds have been obtained. But it will only be when the great majority of those engaged in fattening farm stock acquire the habit of observation and apply its results to their daily practice that we shall see a vast improvement in the economical use of food.

Graziers, for example, where their practice is intelligent, know that the mere change of animals pastured from one field to another is benefical to them. It is likely that the benefit of change arises not merely from the restoring of an appetite or relish for food, which has been jaded or lost by repeated eating of the same food; but a positive chemical or physiological action set up through the new food coming in contact with the old. Thus Liebig himself showed that there existed in the fluids of animal flesh certain very minute substances which greatly influenced its digestibility when partaken of as food. And it is quite a reasonable deduction to draw from such a fact, that those substances arise from the food of which the animal partakes. And as the total amount of all the compounds which play an, or the, important part in the process of digestion and assimilation of food is in itself very small, those substances influencing the digestibility of flesh and the assimilation of food must be very minute. So that in this we find another reason for deciding that the value of feeding stuffs, as shown only by chemical analysis, must in practice be, and is, modified by a very wide variety of considerations almost wholly physiological; although it is possible, and indeed probable, that some of the modifications may be brought about by chemical processes going on of which we know nothing—do not even guess at; so difficult is it to decide on points in which so complicated a structure as the animal frame, and in which the mysteries of life are found, is concerned.

Thus the condition in which the food is as regards its quality must influence its effects upon the animal, and probably set up some chemical processes within the animal as well as bring about certain physiological modifications. We have seen that as changes in the character of a food are important elements in primitive feeding, as by cooking, so also is this of quality likely to be so. Food musty or mity cannot possibly be such a healthy food as that which is free from all disagreeable smell and from living organisms.

The Peculiarities of Animals influencing their Fatting.

We have hitherto considered the subject of feeding of farm stock in relation to animals generally, and noted various circumstances which modify the influence and divide the value of various feeding substances upon them. But when we come to consider the specialities of animals in their individual aspects, we bring up a series of points which again go far to influence and modify the chemical deductions as a food; and which show how very complicated is the function of the feeder. As we, considered individually, differ greatly in our physical or material peculiarities, so do animals. Cattle of the same breed, however good that breed may be as giving fattening stock, show different capabilities of fattening. Of two oxen of the same breed, and apparently very similar in physical characteristics, fed on the same food and on the same plan as regards quantity, time, etc., one will fatten quickly and will pay well, the other will not fatten quickly—perhaps not fatten at all in the feeder's sense of the term.

THE BRICKLAYER OR BRICKSETTER.

THE PRINCIPLES AND PRACTICAL DETAILS OF HIS WORK.

CHAPTER XII.

Projections and Models of the Bonding of Brick Walls of Different Thicknesses, without and with "Returns," highly useful to the Young Bricklayer.

WE would recommend the student of brickwork to project for himself the different courses of work in nine-inch Old English bond, and in fourteen-inch Flemish bond, for return at courses as in fig. 25, and of one wall meeting another at right angles, as in fig. 26, and also to project (see "The Building and Machine Draughtsman") the courses of brick walls up to two and a half bricks in thickness. To aid him in this and in other projections of bond, we would strongly advise him to purchase a set of wooden toy bricks, taking care that they are in due proportion to each other. Or he may very easily make a long strip or feather of wood of the proper width and thickness corresponding to a brick on any scale or size desired, and that being thus determined, he may cut off numerous separate lengths from this, each length corresponding to the length indicated by the scale. By means of these small-scale wood-bricks the student should be able to master a wide variety of combinations in bond, making drawings of each combination as he produces it, the drawings being to some definite scale. Had space permitted we should have given projections of walls up to three bricks in thickness, with returns as in figs. 25 and 26; but the purpose of our paper will be amply served by what we have given in connection with nine- and fourteen-inch walls, which comprise by far the largest part of brickwork executed for ordinary purposes. The illustrations we have given, together with our remarks on "bond" generally, should give the pupil material enough to make projections of a wide variety of brickwork, and to become well acquainted with the combinations of which bricks are capable. This he will be greatly aided in if he should use the small-scale bricks we have here recommended. We now proceed to illustrate the various classes of what may be called general brickwork, taking first the department of hollow walls, or brick walls having a cavity in their interior.

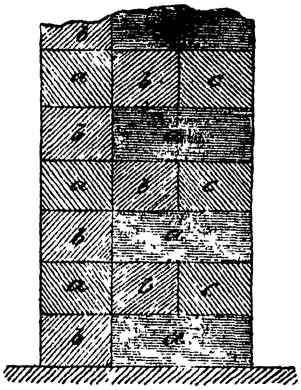


Fig. 30.

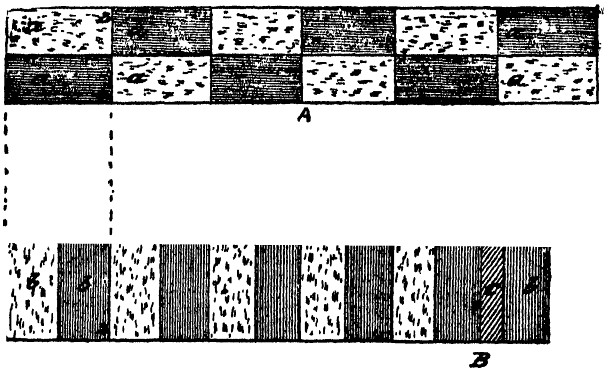


Fig. 31.

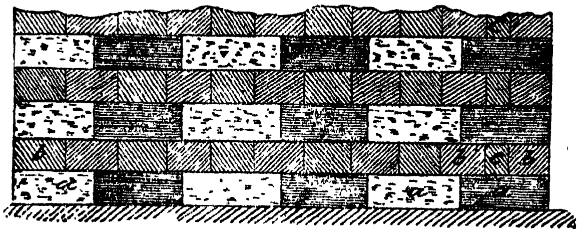


Fig. 32.

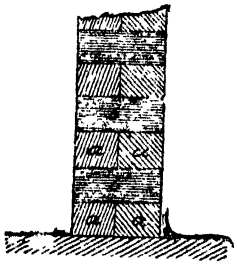


Fig. 33.

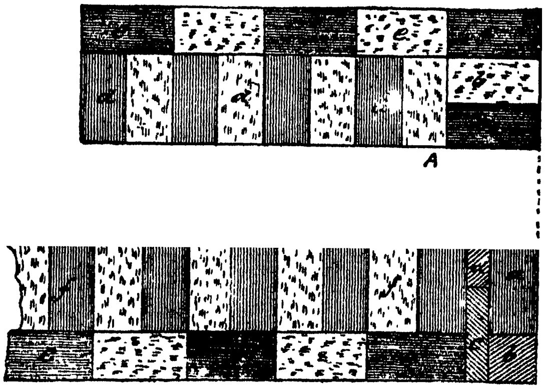


Fig. 34.

Hollow or Cavity Walls.

In the paper entitled "The Sanitary Architect," while treating of foundations, we drew attention to the importance of so constructing them, and the superincumbent walls resting upon them, that they should give as dry a wall as possible; and we there alluded to the system of building walls hollow, or with a space or cavity in their interior, as being now much used with this end in view. At first, on examination of the various systems of building walls hollow, now about to be illustrated, it would appear that they would also be economical in construction, inasmuch as they obviously require fewer bricks; but the advantages in this respect which they offer are, to a large extent, done away with, from the increased cost and from the longer time in bonding and setting of the bricks which the systems involve. Nevertheless, they offer such advantages in regard to the securing of dry walls that they are worthy of being universally adopted where these are desiderated—which, properly speaking, should be in the case of every building designed to shelter living beings. The invention of hollow walls is not a thing of yesterday, but dates back for a considerable period of time, a Mr. Dearn having, in 1829 or thereabouts, introduced his "nine-inch hollow wall," which we illustrate in plan and section, fig. 1, Plate CXLIV. In this the bond used is the "Old English"—already described and illustrated—the lower courses, as shown, being first a row of headers and then a row of stretchers, the next course being a row of stretchers laid "on edge," not "on bed," the next above being a row of headers. The arrangement of the two courses is shown in section to the right; the hollow spaces in alternate courses being formed by the rows of stretchers on edge. In Silverlock's system of hollow wall, as illustrated in fig. 2, Plate CXLIV., "Flemish bond" is used, the bricks being set on edge, both in the stretchers *a a* and headers *b b*, the header bricks *b b* going "through" from front to back of wall, and thus forming a strong "bond" to the whole system. The diagram in B gives a section of A on the line 1 2, showing how the headers *a a* pass through from front to back of wall. This, although nominally in Flemish bond, is an irregular bond, as shown in the part elevation in diagram B, fig. 2, Plate CXLIV., as the courses are deeper than usual, the breadth of the bricks giving the height of the courses in place of the thickness as in ordinary bond.

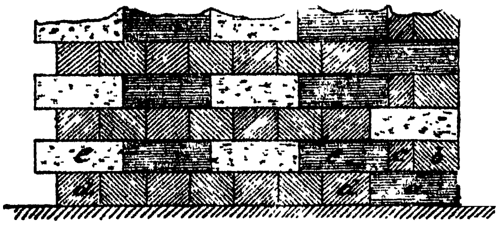


Fig. 35.

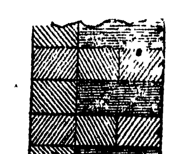


Fig. 36.

The method of giving a hollow brick wall eleven inches thick with a two-inch cavity is illustrated in figs. 3 and 4, Plate CXLIV., and consists in simply leaving a space *a a*, in fig. 3, Plate CXLIV., of two inches between the stretchers *b b b*, advancing the inner faces of these the same distance beyond the ends of the headers—thus forming a series of cavities or hollows two inches wide in the centre of the wall, the same being repeated in the inside of wall, should "firring" or timber battens be nailed or secured in the inside, as shown by the double dotted line, *a a*, fig. 4, Plate CXLIV., on which the plastering is laid; or should this not be adopted, and the plaster laid at once upon the inside, the projecting faces *b b* of stretchers, and the indentations between those ends and heads of the headers *c c* form excellent "keys" or bond for the plaster. In fig. 3, Plate CXLIV., diagram A shows the first course of the headers, *a a*; B the second course of stretchers, *b b*, with space between them, as *a a*. The dotted lines in each show the courses placed above each. The front face of the stretchers *b b* in B being flush with the end face of headers *a a* in A, as shown in section at *d e*, and a space of two inches being left between the stretchers, the second or inner stretcher, as *c* in A, fig. 4, Plate CXLIV., projects beyond the ends of the headers, this forming the spaces as *b b* in A. Sketch to the right. B in same figure, gives an elevation. In fig. 5, Plate CXLIV., in diagram A we give the first course, and in B the second course, of another system of hollow wall, in which the thickness is equal to a brick-and-a-half or fourteen-inch wall. Diagram C, fig. 5, Plate CXLV., is part elevation. In this the "headers" *a a*, *b b*, alternate, showing alternately to the front as *a a*, and to the back as *b b*, two stretchers, as *c c*, *d d*, being placed between two headers. In fig. 7, Plate CXLIV., we give first and second course of an eighteen-inch hollow wall. Fig. 2, Plate CXLVI., is the first course of another method, showing the return wall at a corner, fig. 3, Plate CXLVI., being the second course of ditto, two bricks thick. The front wall, as *a a*, shows the course in "Old English bond," the return wall, *a b*, in "Flemish bond."

THE STEEL MAKER.

THE DETAILS OF HIS WORK—THE PRINCIPLES OF ITS PROCESSES—THE QUALITIES AND CHARACTERISTICS OF ITS PRODUCTS.

CHAPTER IX.

Process of making Crucible Steel.

THE form of furnace used in making crucible steel in the ordinary way is that known familiarly as the coke hole or melting hole. The furnace is of but small dimensions, capable of holding, as a rule, but two of the crucibles we have described; but several of these small furnaces are placed in line, a flue common to them all maintaining the draught by the aid of a chimney, tall enough to keep up a very strong draught. Each furnace is lined with a refractory material, such as fire-brick or the siliceous stone known as ganister, used in the iron and steel manufactures, where very high temperatures are required. To prepare the crucibles for the high temperatures to which they are subjected in the furnace, they are first treated in a separate furnace to a species of annealing or tempering. They are placed along with their covers upon a bed of red-hot fuel, in their special furnace or annealing grate, in lots of twenty, bottom upwards; the spaces between and surrounding them are then filled with coke, and the fire urged by ordinary draught till the desired heat is obtained. They are then removed and placed in the coke or melting hole furnace; where they are subjected to a strong heat, to prepare them for their separate charges of steel—for which they are ready in about twenty minutes or thereabouts, according to the temperature attained. The steel, broken up into small pieces and carefully assorted in order to obtain as definite a quality as possible, is then supplied by means of a long iron funnel. Each pot as it is charged has its cover placed upon it, and the full heat of the furnace applied. At the end of three and a half hours, or thereabouts, the fusion is complete—fuel having been added to the furnace at regular intervals of forty-five minutes. The precise condition of melting or fusion is ascertained by pointed rods which are passed into the crucibles, the covers being previously removed. Through long practice the workman knows by the "feel," so to say, which the mass of molten stuff gives under the probing and stirring action of the rod, whether the precise condition or degree of fluidity is reached. The masses of slaggy vitrified matter which are found to adhere more or less to the crucibles in consequence of the high temperature to which the fuel is subjected are cleared from the crucibles by stirring from below the grating of the furnace, and are then lifted out by means of tongs which embrace them tightly. The crucibles, with their burden of fluid steel, are carried off to the place where the moulds or ingots are placed which receive it. Before being poured into the ingot moulds, the steel is allowed to stand for a short time, slightly to reduce its temperature; and when the mould is filled, its mouth or aperture is closed up with a cast-iron plug, or more readily with a mass of sand,—this being done in order to prevent the top of the ingot from becoming spongy or honeycombed, which it would otherwise become if the gases were allowed to escape during the process of solidification. The ingots or moulds are made of cast iron lined by various substances to prevent the adhesion of the steel to their surfaces. The great heat of the furnace is found to weaken the strength of the crucibles, highly refractory as are the materials of which they are made; so that on being passed through the furnace for a second charge, the weight of that is reduced.

Crucible or Cast Steel (*continued*).

Our readers may have heard of the heavy objects used in engineering work made of cast or crucible steel, of which possibly the celebrated steel works of Krupp, at Essen, in Prussia, have produced the largest examples, as in his well-known steel guns. Those articles are produced by combining the contents of a large number of crucibles, these being poured at the same time into the mould; or the contents of the crucibles are poured in the first instance into a ladle large enough to contain the desired quantity of steel, which is finally poured into the mould. When the object is very large, requiring the contents of a great number of crucibles, the reader may judge of the nicety required in adjusting the number and in manipulating them so that the steel will be so poured into the mould that the whole mass will be of uniform quality or homogeneous throughout. To insure this, the organisation of the men engaged in bringing up the different lots of crucibles must be very perfect; for the great object is to secure a continued supply of steel in the liquid condition; the least degree of "setting" of the metal in the mould would be fatal to the integrity or uniformity of the object cast or moulded.

In making crucible steel it is obvious that its quality is wholly dependent upon the skill of the workmen in selecting the steel bars to be broken up and put into the crucibles to be melted. And this, of course, necessitates a thorough acquaintance with the blistered steel of which the selected bars are formed. The finer the blistered steel, the finer the crucible steel; and the finer the wrought or malleable iron from which the blistered steel is made, the finer the blistered steel resulting. The finest of all crucible steel is made from selected bars of blistered steel, known as cement steel, which again is made from the finest brands of Swedish bar iron. The reader will thus see that the quality of crucible steel is dependent upon the mixture of the blistered steels, and upon the knowledge which the workman or manager has of the varieties of the latter.

The Making of Steel from Cast Iron.

We have in preceding paragraphs in this chapter described the methods which have been brought out of making steel direct from the ore. We now take up, as in the natural sequence of the subjects, the methods for making this metal from pig or cast—or, as it is often termed, crude iron. We have seen that in the Siemens process of making steel direct from the ore there is a modification of it in which scraps of wrought iron are used as well as of pig-iron. What is known on the Continent as natural steels are produced by the agency of refining furnaces, very much in the same way as that of the Catalan process—by which, as we have said, steel is produced direct from the ore. The principal feature of this system of "natural steel" making is the blast of air produced by artificial means, and applied very much in the same way as in the Catalan process, with this difference mainly—that the blast is much more powerful; by which more oxygen is, if not forced through, at least brought in contact with, the surface of the metal in a given time than in the older and more simple process. The Styrian steel long possessed a high reputation, and it was produced on this system of treating crude or cast or pig iron with a blast of air in an appropriately arranged furnace.

We now approach that period in the history of steel making in which were produced those methods which have revolutionised the modern trade, and introduced an entirely new era in the manufacture of steel, by which masses of this truly precious metal are produced in weights, and at a saving both of time and of cost of production, far exceeding the capabilities of all other processes previously practised, and in a way which, from its comparative simplicity, has outstripped the dreams even of the most sanguine of inventors.

In connection with the one of those modern methods—for there are strictly only two, as we shall hereafter see—every one has heard of the name of Bessemer steel. But it is not every one who knows the details of the history of this great discovery—the difficulties the inventor had to encounter, the opposition with which he had to contend, before he succeeded in establishing beyond a doubt that his system was something vastly more important than a mere scientific theory, however clever and acute in its conception or however accurate in its deductions. It was not merely that the inventor had to meet the indifference, general and special, with which the vast majority of new things, however good, are received: this, and the ridicule with which his proposition was greeted—nor less, though harder to bear, the personal insinuations as to motives and aims—he had to endure with what patience he could, and that was required in no trifling degree. But he had to pass through even a greater trial of this by no means common virtue; and it must have been a still severer trial of it when he had to meet the treatment his discovery received at the hands of many scientific men, belonging to the very class to whose antecedents, hopes and aspirations, he was justified in believing that his discovery would appeal so strongly. At the very least it would have, the inventor was justified in thinking, however fully and severely tested, a fair field, and be brought into the arena of that calm discussion which every scientific discovery should receive. But this was not to be; and although not a few men of science, as profoundly gifted as they were fair and considerate in their estimate of the value of new things, treated the discovery of Bessemer with all the satisfaction which a knowledge of its truth gave them, there were others who so far forgot what constitutes the very spirit of modern inductive science, which admits of no assertions or assumptions but deals only with facts, that they, not content merely with statements of theories which they seemed to value only in so far as they might be made antagonistic to the new discovery, denied the facts which such trials as were carried out made abundantly clear. All this was bad enough, and difficult for the inventor to bear with equanimity and patience; but worse remained. He would have been justified in supposing, if the world generally treated his discovery with indifference, if men of science in their eagerness to detract from its value forgot what was due no less to themselves as individuals than as representatives of true science, that at all events his discovery would have been received with delight by the ironmasters, as one likely to open up to them a new source of trade, by giving them facilities for creating with greater ease and in larger bulk than had ever been within their reach a material even more valuable for the wide range of industrial purposes than that which they with the old and established system could manufacture. But this also was was not to be. It is needless now to detail the variety of opposition offered to the invention by "the trade," although it is right in the interests of history—nay, in that of true progress in the material advance of the people—to recall the fact that it was as bitterly carried on as it was persistent and long continued, as if the object of the inventor had been to injure rather than enormously to benefit their trade. And it seemed, so to say, to be but the very irony of fate that the apparatus erected by one firm specially to prove that the discovery was in fact no discovery at all—that it was based upon a false theory, founded on an erroneous deduction—was precisely the very means of proving that the discovery was based on a sound foundation, its deductions accurate and precise.

THE IRON MAKER:

THE DETAILS OF HIS WORK AND THE PRINCIPLES OF ITS PROCESSES.

CHAPTER VIII.

THE charge in the case of Barrow-in-Furness furnaces per ton of iron produced is as follows:—

	Cwt.
Raw ironstone.	34
Darlington coke	from 19 to 21.
Limestone	from 6·5 to 7.

As a rule the proportion of *ore* in the "charge" is such as to give about 50 per cent. of iron. Following this proportion, three parts of ore, two of coke and one of limestone may be given roughly to indicate the average ingredients of a charge.

The following tables may be useful as showing what charges are in common use.

(*a*) *Rich ore. Ulverstone Hæmatite.*

Red Hæmatite raw	34 to 34½ cwt.
Durham coke	18 to 18½ „
Limestone	5¾ „

(*b*) *Poor ore. Cleveland district.*

Cleveland ore, 30 per cent. iron	8 cwt.
Limestone	22 „
Coke	6 „

(*c*) *Mixed ores. South Staffordshire.*

Mixed ores	28 cwt.
Cinder (tap and flue)	2 „
Dudley limestone	9 „
Coke	16 „
Coal	2¼ „

The quantity of carbon required varies according to the quality of the ore; the poorer the ore the greater the amount of carbon, and *vice versâ*, only a small percentage of carbon being required for rich ores.

The Practical Work of the Blast Furnace.

Much of the practice of blast furnace management comes very much under the thumb-rule style of treatment, but which, from what we have said, is nevertheless sound in principle, at least in many of its aspects; and the more recent investigations of science have shown that while science has not been thought of by the workers, certainly not explained in detail by them, yet they have been in large measure following its dictates after all. At the same time it must not be forgotten that to strict scientific investigation the manufacture of iron is under the greatest obligation; and when we remember those recent discoveries in metallurgy which have revolutionised the practice of more than one of its departments, it will be seen that the practice will yet be largely influenced by and be greatly indebted to the science of the future. The true conjunction, after all, which the reader should bear in mind, is science with practice; not the one without the other, or even science *and*, but, as we have put it, science *with* practice. The distinction seems a nice, almost a paradoxical one; but the youthful reader will do well to think it over and trace its practical outcomes, which, if he does, will show him how important they are.

From the varied practice of blast furnace working in various districts, it may be stated that the rule is deducible, that the proportion of ore in a charge is such as to yield about 50 per cent. of iron. Following out this proportion, three parts of ore, two of coke, and one of limestone, may be taken roughly to indicate the average ingredients of a charge. The quantity of carbon required (coke or coal) varies according to the quality of the ore used; the poorer the ore the greater the amount of carbon required, and, *vice versâ*, the smaller percentage of carbon for rich ores. The ores varying, as we have elsewhere stated, in quality, a fair average is generally adopted by mixing the poorer varieties with the rich, the object being to obtain, as a result, the average of 50 per cent. of iron, as above named; and the proportions of ore, fuel and flux, as just given, are placed in the furnace or "charged" to it in alternate "charges." The great iron-making districts of the kingdom are represented by the "Staffordshire," the Yorkshire (better and more widely known as the "Cleveland"—*i.e.*, the district of which Middlesbrough may be taken as the working centre), and the "Ulverstone," of which the new but now densely and largely populated town of Barrow-in-Furness (Lancashire) may be taken as the centre. These three districts may be taken to represent the three classes of ores from which the English iron is made; of which the extremes are Ulverstone, which represents the best or highest, Cleveland that of the worst or poorest ores; and Staffordshire, as representing what may be called the middle-class ores. The ores of Scotland, as we shall see, may come under another category, the chief feature of which is the Black-band ores, of which Staffordshire, by the way, yields a good supply. Mr. Williams, in his very valuable Cantor lectures—given under the auspices of the Society of Arts, and which we strongly recommend to the notice of the readers—on the subject of "Iron and Steel Making," gives the proportion of the "charge" used in the three representative districts of English iron making in the order in which we have above referred to them. From these we prepare the following statement:—In the first or Staffordshire district, 28 cwt. of mixed ores and 2 cwt. of cinder: these represent the ore part of the charge. The "flux" department is represented by 9 cwt. of Dudley limestone, and the "fuel" by 10 cwt. of coke and 2¼ of coal. In the "Cleveland" district the "charge" is made up of 8 cwt. of the ores of the district, 2·2 cwt.

of limestone, and 6 cwt. of coke. In the Ulverstone, otherwise known as the "Red Hæmatite" district from the fine quality of the ore there so abundantly met with, the "charge" is made up of from 34 to 34½ cwt. of raw red hæmatite ore, 18 to 18½ cwt. of Durham coke, and 5¾ cwt. of limestone. Taking these representative charges, we find that in the Staffordshire district the proportion of lime flux to the ore is about one-third, and of fuel to the ore about two-thirds. In the Cleveland district the proportion of lime (flux) to the ore is between one-third and one-fourth, and of fuel to the ore about three-fourths. In the Ulverstone district the proportion of lime (flux) to the ore is about one-sixth, and of fuel to the ore a little more than one-half. In these it will be noted that, so far as the Ulverstone district is concerned, the difference in the proportions of flux and ore in its practice is very great, as compared with the other districts. This arises from the richness of the red hæmatite ore, very little silica having to be removed from it by the flux action. It will also be observed that the fuel used in all three districts may be said to be coke—the only exception being the Staffordshire, in which coal is used, but this only in very small proportion, as say one-eighth of the coke. And the reader will also take note that the fact we have but just stated—namely, that the richer the ore the less the amount of carbon derived from the fuel required—is illustrated in the practice of the above representative English iron-making districts. Thus the fuel is required in the lowest proportion in the Ulverstone district, in which the ore is the richest; in the highest proportion in the Cleveland district, in which the ores are the poorest; a medium proportion being required in the Staffordshire district, in which the mixed ores used give what may be called a medium degree of richness.

Whether using raw ores and raw limestone (or flux), or whether roasting or calcining them, be the more economical practice, is a point very much disputed amongst practical, and by many scientific men.

The Process of Reduction in the Blast Furnace.

The following remarks, it must be distinctly understood, refer specially to the *cold* blast, unless otherwise expressed; the subject of the *hot* blast will have a separate paragraph devoted to it. In the case of the cold blast a quantity of the heat of the furnace is absorbed in raising the air to the requisite temperature much greater than that required when the blast is already heated to a certain degree; the result is that the maximum temperature occurs at a higher level, and distributed to where it is not required. Hence it sometimes happens that not better iron than forge iron can be obtained. This is a point in regard to the cold blast which it will be well to bear in mind, as giving at the outset some idea of the distinction between the hot and cold blast.

Beginning at the *top* of the charge, where the material is subjected to the least amount of heat, we find that if *raw* ore is used, a veritable process of calcination or roasting is taking place: the ore is not only affected by the heat of the gases which are evolved from the material below, but is acted upon by them *chemically*. The chief substances composing these waste gases are carbonic oxide (CO), which is inflammable, burning with a blue flame and forming CO_2; carbonic acid (CO_2), which is incombustible; cyanogen (C_2N), and hydrogen, which burns, forming water. Besides these, there are always present various hydrocarbons more or less numerous—compounds formed of carbon of the fuel united with hydrogen. In this action much depends upon the height of the furnace. When high or tall furnaces are used, the ore becomes roasted before the carbonic acid evolved can prove injurious by uniting with the lime mixed with the charge. But, on the other hand, tall furnaces possess this disadvantage, that the pressure on the gases in immediate contact with the iron is increased, and thereby the pressure on the iron is increased in proportion. Now, this increased pressure has a deteriorating effect upon the quality of the iron, in a manner which will be referred to hereafter.

Immediately below the point at which this calcination of the ore takes place the ore undergoes a certain amount of *reduction*. In other words, the oxygen with which the iron is combined unites with the lime which is present in the charge in the form of some variety of *flux*, such as carbonate of lime; creating the combination known as calcium oxide. Below this region of reduction we come to the part of the furnace where it is said to be at a "full red heat"—*i.e.*, about the middle of the body or cone of the furnace. At this zone or band the iron is exceedingly porous and spongy, and so extremely active that it will seize upon and combine with the elements of the nearest substances surrounding it. For this reason it is termed the "zone of absorption." Examination of a piece of spongy iron will show that it is of a honeycombed structure, consisting of the particles of metal seemingly cohering only very slightly, leaving spaces between. Iron in this condition is pure or impure according to the richness of the ore used: if the ore used in producing it contain few impurities, and these only the less injurious sorts, so will the spongy iron be nearly perfectly pure. The chief impurities ordinarily contained in spongy iron are the "silicates," and mainly for the purpose of removing these it is that some *flux* is added to the charge. This consists of some substance that will unite with silicon, and has a greater attraction for it than iron; the flux usually employed, as we have seen, is "limestone"; and this, as we have also seen, is used in proportion to the richness of the ores and the absence from them of debasing constituents such as silica.

In reference to the results of the blast, the following is the opinion held by Mr. Charles Cochrane, of Dudley, as expressed in a paper read before the Institution of Mechanical Engineers:—"The most perfect action of a blast furnace the writer conceives to consist in the development of the highest temperature needed for the production of the required quality of iron, in a layer or stratum as little removed from the *tuyères* as possible; and the absorption of the heat from the ascending gas by the materials through which it passes, until it leaves the throat of the furnace at the lowest possible temperature. Anything which tends to cause a more perfect absorption of the heat developed in the hearth, or to lower the level of the region of highest temperature in the furnace, will thus be beneficial."

Process of the Reduction of the Ores or Conversion into Cast Iron in the Blast Furnace (*continued*).

We now come to consider, as fully as the space at our disposal admits of, the action of the blast furnace when fully charged and under the influence of the high temperature created by the blast; or, in other words, the process of "reduction" or smelting of the ore as it goes on within the furnace when in full work. As we have seen, the charge of an ordinary blast or smelting always consists essentially of three materials: the ore to be smelted, the flux wherewith to smelt it, and the fuel to produce the necessary temperature. Of these the latter is only combustible, it cannot melt; the two former—ore and flux—are fusible when in combination. And it is not improbable that only *they* are so when subjected to the high temperature of the *hearth*. As the ore, by the influence of the flux, begins to melt, it descends in the furnace, and is soon converted into what we have already described as iron sponge, and which is so called from its porous nature and readiness to absorb and combine with the substances with which it is in contact. It may, however, not be improbable that the gangue, when composed of silicates, is derived from the sponge above the zone of fusion, and if so it leaves that zone capable of doing more work. The sponge being now in a fluid condition, runs down as comparatively pure metallic iron into the crucible or bath at the hearth below. There is thus nothing left in the space below the fusion zone and above the bath except the infusible fuel, and this collects here and remains until it is burned away. From what has been said it will not be difficult now to understand that the quantity of the oxygen burned per second, the amount of lime as compared with carbon, and the relative fusibility of the gangue contained in the iron ore, will in a great measure, if not entirely, determine the height of the mass of fuel in the space above the bath and below the zone of fusion. Generally speaking, there will result a less height of fuel from an infusible gangue of quartz where the silicates or other infusible gangues tend to produce a higher column of fuel. The cause of this is simply that the mass will in the former case remain unmelted and infusible until acted upon by the contact of newly generated carbonic oxide, just as in the case of the sponge itself. It will of course be seen that what heat is employed in melting the gangue in this manner is subtracted from what goes to melt the sponge; there will therefore be less sponge melted and a smaller yield of iron from the furnace. It is also to be noticed that the result of diminishing the height of fuel, as above explained, is that there is less contact of the blast with fuel; consequently an additional supply of fuel is necessary, not only to make good the heat employed in melting the gangue, but also to make up for the decrease of fuel-surface subject to the action of the blast.

Different Zones or Regions of the Fusion or Reduction of the Ores in the Blast Furnace.

As illustrating the different regions — termed technically, as we have elsewhere stated, "zones"—of heat existing within the blast furnace when in full work, we give a diagram in fig. 1, Plate CLXVII., for which we are indebted to a paper read before the Institution of Mechanical Engineers by Mr. Charles Cochrane, of Stourbridge, illustrating the *gradations* of heat in a blast furnace of eighty feet in height. Beginning at the top of the furnace, the space from *a* to *b* represents the zones of reduction and of carbon impregnation; from *b* to *c* is the zone of limestone or "flux" decomposition and also of reduction; the large space from *c* to the dotted line *d* represents the zone of heat interception; and lastly, from *d* to the bottom of the hearth at *e*, the zone of fusion, or the crucible of the furnace. From this it appears that the entire height of the blast furnace may be divided into four principal divisions as regards the gradations of temperature in its interior, as described above. Of these the lowest zone—the "zone of fusion," from *e* to *d*—occupies nearly one-tenth of the entire height, 1 to 10; the next division, from *d* to *c*, more than one-half; the third, from *c* to *b*, more than one-tenth; and the uppermost, from *b* to *a*, about one-fifth.

Coming to the smaller divisions indicative of the varying shades of heat, as decided upon by Cochrane, from the top *f* to point *g* is distinguished as the zone of "black," and proceeding downwards from *g* to *h* is the zone of "dull red heat"; from *h* to *i* the "red-hot" zone; from *i* to *j* that of "full-red"; from *j* to *k* and from *k* to *l* the "bright red" zones; from *l* to *m* the "very bright red" zone; while from *m* to *n* is the zone of "white heat."

THE SANITARY ARCHITECT.

THE PRINCIPLES AND PRACTICE OF HIS WORK, IN HEALTHY HOUSE ARRANGEMENT AND CONSTRUCTION.--TECHNICAL POINTS OF SEWERAGE AND DRAINAGE, VENTILATION, ETC.

CHAPTER V.

On Brick as a Building Material (*continued*).

MUCH of the prejudice which in some quarters exists against brick walls arises not only from their being too thin—a 9-inch solid in place of a 14-inch solid, or a 9-inch solid in place of an 11-inch cavity or hollow wall, for example—but much more frequently from the choice of badly burnt, porous, unsound bricks, and from the scamping way in which they are put together—broken bricks, imperfect bond, and mortar of the poorest quality, which crumbles away in a season or two, being the characteristics of the work. An honestly built brick wall of good, sound, hard, well-burnt bricks, even if only of 9-inch thickness, will be worth far more than a 14-inch or even a two-brick thick wall dishonestly built. It is most mistaken economy to use bad bricks simply because they are cheap, and mistaken policy in building to build quickly. Expense may at first sight be lessened; but it will not be long before the proprietor finds out his mistake in incessant demands on his purse for repairs, or in finding those worse demands upon the health of those who have the misfortune to live within such walls, so thoroughly badly built at first. Another advantage which brick possesses over many qualities of stone—which it may be as well to name here, although it is a quality connected more with the safety than perhaps the sanitary condition of property—is its capability to resist the action of fire. In many cases of fire the walls, or parts of them, if built of stone, are rendered wholly useless even when the fire has not been a very bad one or a "thorough one," from the stone either exfoliating or crumbling to pieces under the action of heat, this being more especially observable in the case of limestones. But walls of brick will often scarcely be injured by a fire of the same degree of intensity, and may be allowed to stand with perfect safety, while the stone ones would have to be rebuilt. This was most strikingly exemplified in the great fire at Chicago, in the United States: the stone houses there, being mostly built of a kind of limestone, were nearly all totally destroyed, the walls crumbling away and breaking completely up; the same with the iron houses; but those of brick stood the intense heat so well that the walls in many instances were left sound. Indeed, several instances showed an unusual quality of brick—namely, the power to resist fire, that is, not to be so easily caught up by surrounding flames. A very remarkable example of this was noticed in the Chicago fire. A brick house, situated in the very midst of a burning district, surrounded on all sides by the flames and heat of burning houses, was, to the surprise of all, when the mass of fire had burnt itself out, found to be still standing, and, what was very remarkable, it had not taken the fire at any point. There is, we believe, much to be learned yet in the direction of safety from fire to be gained by the use of building materials for the external walls.

Expedients to Cure or Prevent Damp Walls.

Where the misfortune exists of a thoroughly damp wall, it is not only a difficult but a costly thing to render it dry. All sorts of expedients have been introduced, and numerous materials have been patented by which damp walls can be made and kept dry. External coatings of tar, although to a certain extent efficient, yet rendering the house exterior hideously ugly, are employed, but these require to be perpetually renewed; coverings of slate, also external and nearly as ugly, are also used; or cement, which is not only ugly, but which, if not honest in quality and in the way it is applied, is very costly, as it lasts no great length of time. Then again there are a host of linings for internal use, which at first, most of them, show signs of efficiency that, unfortunately, do not last long. Although perhaps the most expensive, we believe that no expedient will equal, not only in efficiency but also in its lasting characteristics, an application externally of Portland cement—that is, if the quality be good. Perhaps the best test of this is its weight per bushel, which should not be less than 100 lb.—all the better if it is 110 lb. Of course, all external applications, of whatever kind, must be or should be made at a season of the year when the walls have had as much of the drying season as possible, and should never be applied when the surface is well wetted. But some walls get so thoroughly saturated with damp that it will require a very dry season indeed before the external application can with safety be given.

For rural or suburban houses, in place of the ugly coating for external walls of tar or slate, ivy may be used with picturesque effect, and will be found a capital thing to beat off driving rains. We are quite aware of the fact that the popular notion is, with respect to this plant, that it makes a wall damp on which it grows. It is not so. Examine a wall which is covered with ivy—we mean, of course, a pretty vigorous growth of it—after days, nay, a whole season of wet or damp weather, and you will invariably (we never yet saw an exception, and we have tested many, and still test all examples we meet with) find the wall below quite dry. The fact is, one has only to examine the habit of growth of the plant to see that the rain, however strongly it may be wind-dashed against the leaves, cannot—at least very easily—

reach the wall through them. The leaves dash off the rain and cause it to drip downwards, but it cannot pass under the leaves, and of course not through them; neither can it nor does it pass from above a leaf, for each leaf is more or less covered with the overhanging part—armour fashion—of a leaf above it. Then, again, ivy has this advantage—that while there is a close armour of leaves, the branches are so numerous, and so singularly placed in relation to the leaves and to one another, that the space, as it were, of the covering is honeycombed; thus the wind and air can get freely up through and amongst the "panoply of green and 'dry," acting upon the surface of the wall and keeping it dry: ivy has thus a twofold advantage. It may harbour vermin, but it is not so much of a nuisance in this way as it is supposed to be, or as many other plants are; and it always looks well with rural surroundings. We believe that there are, however, other plants which would give an equally pretty effect, with much of the damp-preventing qualities of the ivy; but the difficulty is in their not being evergreen. Some of the evergreens trained to walls have not the same fine adaptation of leaf surface and branch disposition which makes ivy so valuable for the purpose here under consideration.

The interior of a house has to be or ought to be also dealt with, as well as the exterior or surface. It is unpleasant to incur the reputation of being invidious in the naming of any one material used for constructive purposes, where there are many offering themselves to public notice; but we have found a species of paper, or paper board, known as the "Willesden paper," to succeed when everything else which had been tried had failed. This is the result of a very clever chemical process lately introduced, by which the paper pulp is impregnated with a solution of copper. From trials we have made we believe it to be absolutely waterproof. For the thoroughly saturated parts of interior wall surfaces—and we have examined such in an actually dripping, not moist, but absolutely wet state—the only true remedy, we are inclined to believe, is the application of Portland cement. The expense of this is often lowered by using a heavy proportion of sand; but the proportion of this should never exceed three parts to one of cement, which—and we cannot too often name this—should be of the finest quality. There is a variety of what are called damp-proof papers used for lining the interior surfaces of walls; but for our part we have as yet not met with one quality which deserved its name, save the above-named "Willesden"—so called, we presume, from the fact that the manufactory where it is made is in the suburban district of London known by this name.

After all, the best thing is prevention, and the way to secure this is to use the best materials, and to build them in the best way; and it is only in the case of walls already built that curatives, or so-called curatives, are to be used. But there are some walls so bad that they never will be cured, except in the fashion of curing a bad leg by cutting it off—that is, by pulling down the walls and putting up good sound ones; in point of fact, there are some houses so damp that they are not fitted for "habitations for humans."

We believe that under more enlightened views as to what sanitation is, and how it should be carried out, the day will come when a damp house will be looked upon as no less a nuisance than some nuisances are now looked upon. There are hundreds of damp houses now existing throughout the kingdom, which are as surely killing their inhabitants, or rendering their lives unhealthy, as any houses in which there is a condition of defective or thoroughly neglected drainage or sewerage, or overcrowding. A lodging-house—under the Act—is not allowed to be overcrowded: why should a thoroughly damp house be allowed to be inhabited? The answer is obvious: in the one case the effects of the evil are more immediate, more easily seen, and, we should say, more thoroughly and widely understood, than are those of the other—which are not seen or obvious, but on the contrary, as we have already said, so exceedingly insidious and occult, and we regret to have it to say, not at all thoroughly and widely understood even by medical and high sanitary authorities—that is, if we are to judge from the way in which the subject is considered and dealt with—or often, we should say, *not* considered and *not* dealt with. Well would it be for those who are compelled to live in thoroughly damp houses if this condition of matters in relation to sanitary house construction did not exist amongst us, and to such a wide extent.

House Drainage.

In preceding paragraphs we have discussed the various points connected with the site of the house and the means necessary to be taken for the prevention of damp in the floors and walls—the importance of which points must not be overlooked or underestimated by those desirous to erect or to inhabit one or other of the various classes of domestic buildings, if the maintenance of health be considered essential. We now proceed to the discussion of the important subject of house drainage and sewerage. This is generally considered to be the most important department of sanitary construction—one which takes precedence of all others. But while thoroughly estimating at the highest value its claims to consideration, it must not be overlooked that there are other departments which claim attention.

THE BUILDING AND THE MACHINE DRAUGHTSMAN.

CHAPTER XIX.

At end of last chapter we illustrated a method of transferring distances from one line to another: this is further illustrated in fig. 5, Plate CCXIV., in which the diagram A may be taken to represent the plan of a building the outline of which is the Greek cross with equal arms, and which is one example of finding the projection by elevation from plans, and *vice versâ*. B is the projection of the sides *a b*, *c d*, *e f* of A, C the projection of the right-hand side of A, while D is the projection of the part viewed from and at right angles to the arrow *h*; and projected in a line *i j*, oblique to the base line which is parallel to the line *k l*. From the points (in A) *c*, *d*, *e*, *f*, *q* and *g*, draw at right angles to the oblique line or diagonal line *c g* or *k s*, the lines *c m*, *d n*, *e o*, cutting the line *k s*. Next, from the point *k* as a centre, with *k m*, *k n*, *k o*, etc., describe arcs, cutting the line *k k* in the points *t*, *u*, *v*, etc., and from these draw lines at right angles to *k k*, as at *i w*, and make *i w*, *j x*, equal to *a′* B (in B), and join *w x*: *i w x′ j* is the projection of the plan of B in the side *c g′*, looking at it in the direction of the arrow *h*. Properly the lines, as *i w*, *x j*, should have been in the line *k x*; but as this would have confused the drawing by the lines mixing with those of B, we have transferred the line *k x* to *i j*. Another example of angular projection is given in fig. 6, Plate CCXIV., which gives the projection of a square prism in plan B and elevation A, the base being placed obliquely, as at C in fig. 2. Lines parallel to the base line *b d* in A are drawn across from the points *a*, *e*, *c*, *f*, in B, to obtain the base *a c e f*, and the top *g h i j* of the prism at D. Then from these points perpendiculars are drawn cutting the base of the prism *k l*, which is placed at an angle of 30° to the "base line" *b d*. The accented letters in the elevation C show the projections of corresponding points in plan B and projection of plan in D. From *a′*, *c′*, *f′* and *e′*, on the line *l k*, draw perpendiculars to *l k*, as *a′ h′*, and make *a′ h′* equal to the height of the prism. The converse operation—finding the plan, the elevation being given—will be understood from what we have already given in connection with preceding figures.

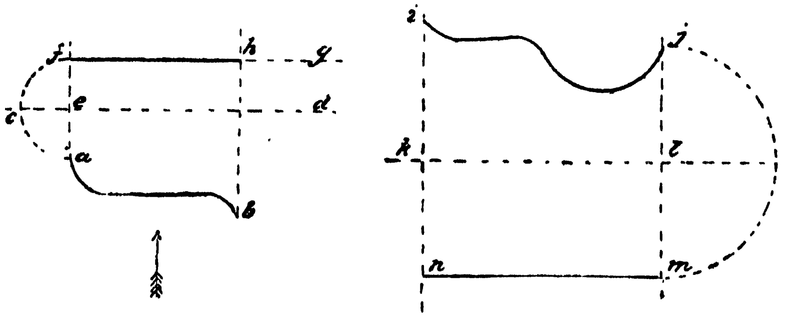


Fig. 37.

We have seen in preceding diagrams how the different views of the same object drawn in plane projection differ, so to say, in appearance according to the point from which it is looked at; the points of the object giving the outline of it being projected, to use the technical language of the art, towards the eyes in straight and parallel lines. Thus let the line *a b*, fig. 37, be a curved line in plan—that is, as seen when looked down upon at right angles to the surface of the paper on which the line is projected. To find the elevation of this as looked at in the direction of the arrow 1, let *c d* be the base line of the projection of elevation. From point *a* draw at right angles to *c d* the indefinite line cutting *c d* in *e*. From *e* with elevation *e a* set off to *f*, cutting *a c f* in *f*.

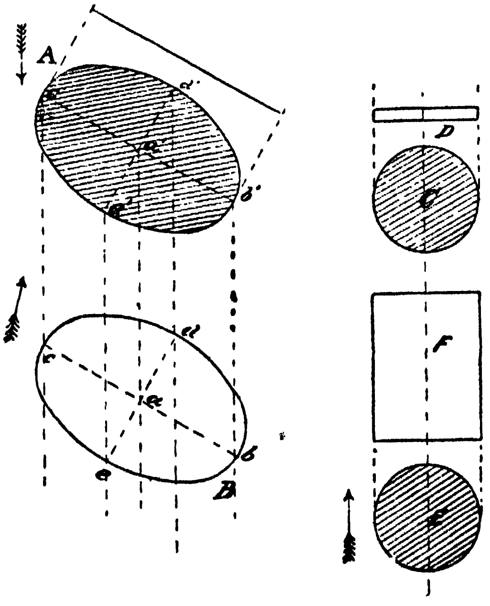


Fig. 88.

From *f* parallel to *c d* draw an indefinite line *f g*; from point *b* of curved line draw parallel to *a c f* the line *b h*, cutting *f g* in *h* : *f h* is the elevation of the curved line *a b*, looked at in the direction of the arrow 1. Here we see the elevation of a curved to be simply a straight line; so also in the example at *i j* in the same diagram (37), the elevation of this curved line, when looked at in the direction of the arrow 2, being simply a straight line *m n*. In this the base line *k l* is below the plan, but the method of finding the elevation is the same as at *a b f h*.

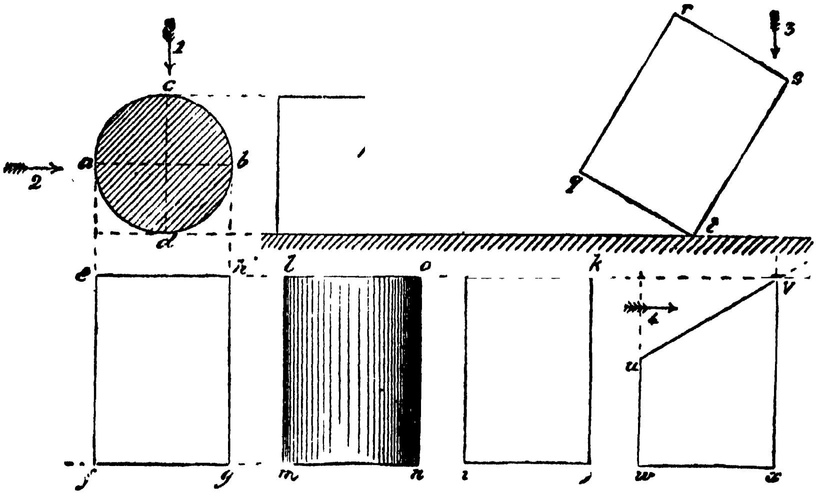


Fig. 39.

Again, when a circle is looked upon in plan as at A in fig. 38, in the direction of the arrow A, the projection at B B is the same; how this projection is obtained the reader has had already explained in preceding paragraphs. But if the circle be looked at in the direction at right angles to c' b' in A, the projection obtained is no longer a curved, but simply a straight line shown at upper side of A. If the circle A A was a mere plane surface in plan, the elevation would be a line having length only, not depth or breadth. But if the circle represented a flat circular plate having a defined thickness, as at D in fig. 54, the elevation would be as at D. In the technical language of mechanics a thinnish circular plate is called a disc, as at C; and may be of varying thickness, but always relatively thin. If the depth or thickness is increased, as at F, it is called a drum, and if the thickness is so much increased in relation to the diameter of the circle, we then use the term depth or height, and call the object a cylinder

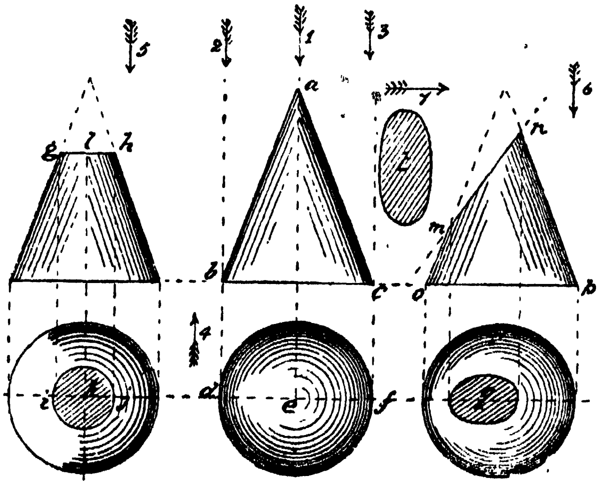


Fig. 40.

In fig. 39 we give different views of a cylinder, the plan of end of which—both ends being obviously alike—is shown at *a b c d*. The elevation of this, as seen in looking at the plan *a b c d* in the direction of the arrow 1, is simply a rectangle, as *e f g h*, the distance *e f* being equal to the height of the cylinder, the distance *e h* equal to the diameter *a b* or *c d* of the circle in plan, the lines being carried down from which give the lines *e f*, *g h* of the elevation. Looked at as thus projected, with all its lines of equal thickness, the elevation might represent a mere flat surface, and it could not be said whether it was a projection from or a part sunk into the general surface; by giving the lines *ij, jk* thicker (see preceding diagram on shading), we should then know that it projected; but the outline *efgh* could only be known to be a cylinder by being shaded as at *l m, n o.* If the cylinder in plan at *a b c d* was looked at in the direction of the arrow 2, it might be an elevation precisely the same as *efg h*, but in *p* it is shown as lying on its side. At *q r s t* it is shown as tilted up, the base *q t*, corresponding to *f g*, being oblique to the base line. In this position, which is technically called "canted," if the cylinder be looked down upon in the direction of the arrow 3, the end has no longer the appearance of a circle, as the end *e h* of the cylinder *efg h*, but is an ellipse, the shape of which—that is, the length of its major and minor axes (see "The Geometrical Draughtsman")—varies in proportion to the obliquity of the line *t q* to the base line of the projection. Again, if the end of the cylinder, as *u v*, be not parallel to the other end or base *w x*, but oblique to the height, as *x v*, then, if the cylinder so cut by a line oblique to its axis be looked at in the direction of the arrow 3, the line is no longer a circle, as at *a b c d*, but an ellipse; so also is it when the cylinder thus cut by an oblique line is looked at in the direction of the arrow 4. The method of projecting a "canted cylinder," as at *q r s t*, and one cut by a line oblique to its axis, as at *u w x v*, will be shown presently in succeeding illustrations.

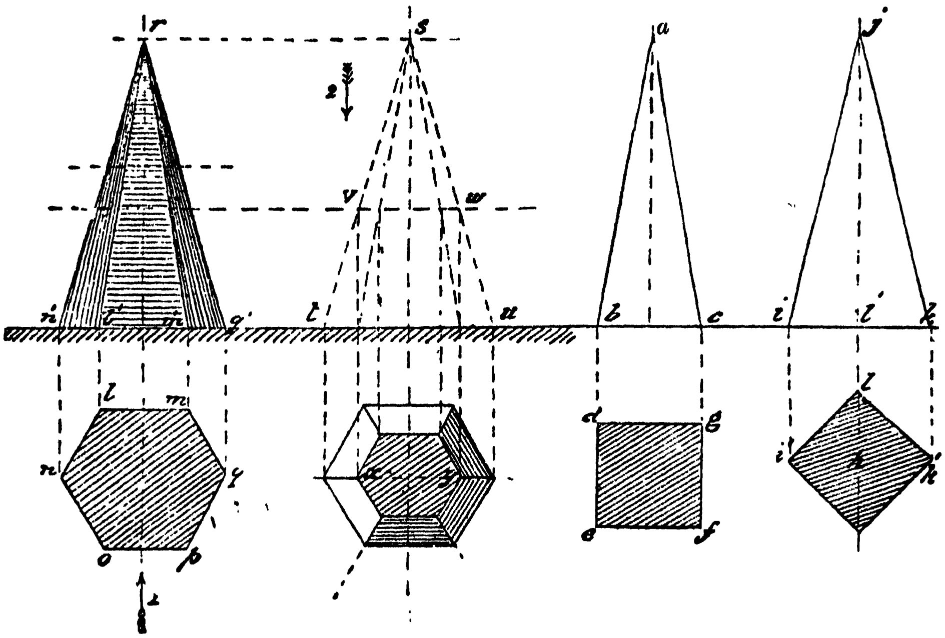


Fig. 41.

The subject now under consideration, the dif[illegible]ent views at different points, is further illustrated in the case of the cone, as *a b c*, fig. 40. This is shown in elevation; but when in plan, as seen when looked down upon, as in the direction of the arrow 1, it is simply a circle, as at *d e f*,—this being bordered, so to say, by the lines projected from the points *b, c*, in the direction of the arrows 2 and 3, parallel to the line of axis *a c*. If the cone were looked at in the direction of the arrow 4 the plan would be a circle, just as at *d e f.* If the cone were cut by a line parallel to its base, as at *g h*, if looked down upon in the direction of the arrow 5 the plan would be as at *i j*, the outer circle being the same as at *d e f*; and the inner *i j*, showing the cut top at *g h* in elevation, would be obtained by projecting the points *g, h*, by lines parallel to the line of axis *l k*, to the points *i, j*, cutting any line, as *i f*, parallel to the base *b c* of the cone. If the cone was cut by a line *m n*, oblique to its base *o p*—if this elevation *o m n h* was looked down upon in the direction of the arrow 6, the plan of top would no longer be a circle, as at *i j*, but an ellipse, as at *q*, the general plan of the whole cone being as at *q r*. If the face *m n* of this cut cone was looked upon in the direction of the arrow 7, it would show the appearance of an ellipse, as at *t*. These two diagrams, figs. 39 and 40, give the basis of an important series of constructions made useful to the mechanic and the builder in the preparation of working drawings. Some of these will form the subjects of succeeding paragraphs in these important departments.

In fig. 41 we give at *a b c* the elevation of a pyramid, the plan of which is at *d e f g*. If the base be placed obliquely to the base line of projection of elevation, showing a plan as at *h*, the elevation will be as in *i j k*.

THE GEOMETRICAL DRAUGHTSMAN.

His Work in the Construction of the Figures and Problems of Plane Geometry, Useful in Technical Work.

CHAPTER XII.

Figures of Three Sides—Triangles. Terms, Definitions, and Points connected with the Figure or Surface.

There are three kinds of triangle, defined by the relation of their sides. The equilateral triangle has its three sides equal; the isosceles triangle has only two sides equal; and in the scalene triangle the three sides are unequal.

In every triangle the largest side is always opposite to the greatest angle, and conversely; that is to say, the largest side and the greatest angle are always opposite one another.

With reference to their angles, we divide triangles into three kinds: the rectangular triangle, or that which has a right angle; the obtuse-angled, or that which has an obtuse angle; and the acute-angular triangle, one in which all the angles are acute.

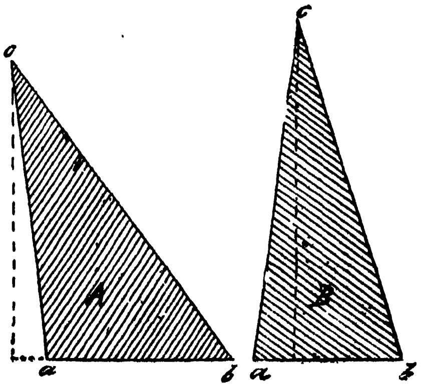


Fig. 63.

The sum of the three angles of any triangle whatever is equal to that of two right angles, and consequently 180°. From this attribute or characteristic we draw the following conclusions:—First, that when we know the two angles of a triangle we can always find the third by subtracting the sum of the two from that of two right angles, or 180°. Secondly, that there can be only one right angle in a triangle, for there only remains for the two others the 90°; the three taking up, as we have said, 180°. Thirdly, that the two acute angles of the rectangular triangle are together equal to 90°, and are, consequently, the complements of each other. And, fourthly, we conclude that there can only be one obtuse angle in a triangle, since there remains for the two others only a number of degrees less than 90.

We take, as base of a triangle, one or other of its sides, as *a b*, fig. 63, and the height *a d* is the perpendicular line on this base or on its prolongation, as *a d* dropped from the summit *c* of the opposite angle to the point *d*. The line in a right-angled triangle as *a b*, fig. 69, or *c b*, fig. 63, is called the "hypothenuse." The measurement of the surface of the triangle is obtained by taking the half of the product of its base by its height. Then, all the triangles which have the same base and the same height have the same surface.

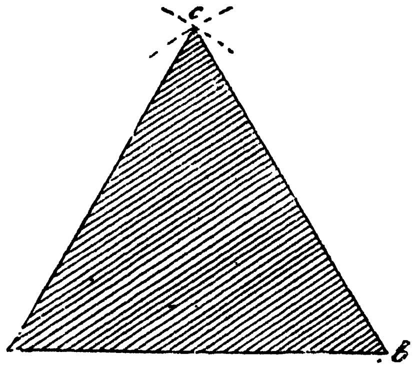


Fig. 64.

To Describe, Construct, or Draw an Equilateral Triangle.

The equilateral triangle is, at the same time, equiangular, and consequently it is the regular polygon of three sides. To construct the equilateral triangle, it is necessary to know the length of its side. Draw, first, a straight line equal to its length, as *a b*, fig. 64; from its two extremities, as *a* and *b*, as centres, and with a radius equal to this same line or side, *a b*, describe two arcs which intersect in the point *c*; join their point of intersection *c* to the extremities, *a*, *b*, of the side *a b* already drawn: this completes the construction of the equilateral triangle.

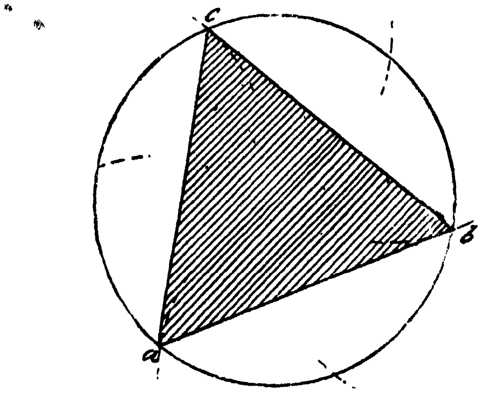


Fig. 65.

To Inscribe an Equilateral Triangle in a given Circle.

We have already said that every regular polygon can be inscribed in a circle; we proceed now to show how the equilateral triangle may be inscribed in a circle.

From any point, as *a*, fig. 65, taken on the circumference of the circle as centre, and with the radius itself of the circle, describe an arc which will cut it in two points, as at *b* and *c*: the straight line which will join these two points of intersection will be the side of the inscribed equilateral triangle. Each angle of the equilateral triangle is equal to 60°, or the half of one-third of the 360° in the whole circle.

To Describe, Construct, or Draw the Isosceles Triangle.

We have said that the isosceles triangle is one which has only two equal sides (fig. 66). The angles opposite to the equal sides are also equal. When the third side is much larger than each of the two others, the isosceles triangle is then like the triangle A, fig. 66; it is this figure that is adopted for the roof trusses of buildings. To construct the isosceles triangle when we know its sides, draw as base the one side which is not equal to any of the two others, as *a b* in B, fig. 66, from its two extremities *a*, *b*, as centre, and with a radius equal to the length of one of the two equal sides, as *a c*, *b c*, describe two arcs, intersecting in point *c*, and join their point *c* of intersection to the two extremities *a*, *b*, of the first side drawn.

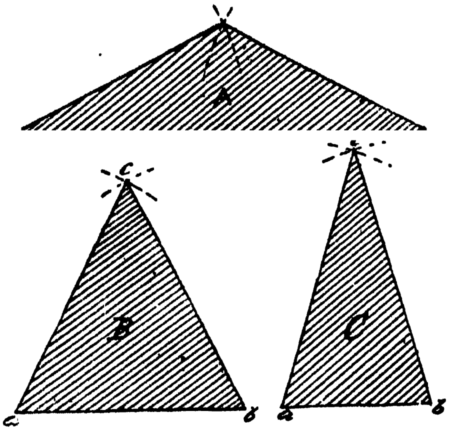


Fig. 66.

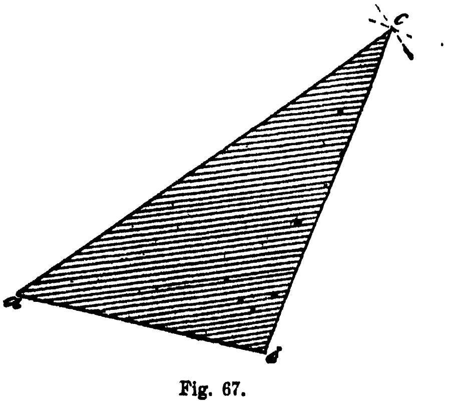


Fig. 67.

To Describe, Construct, or Draw the Scalene Triangle.

The scalene triangle is one the three sides of which are unequal, which makes the angles unequal, as in fig. 67. To construct this triangle, when we know the length of its sides, draw one of them, as *a b*; from its two extremities *a* and *b* as centres, and with radii respectively equal to each of the two other sides, as *a c*, *b c*, describe two arcs intersecting in the point *c*; from their point of intersection *c* to the extremities *a*, *b*, of the first side, draw lines, and the desired scalene triangle is described.

To Construct or Draw a Right-Angled Triangle.

The right-angled triangle is one which has a right angle, as in fig. 68. In this angle the side *a c* (*b c*) is called the "hypothenuse," this side being opposite to the right angle *b* in A, and *a* in B, and which is always the largest, since it is opposite the largest angle. When the two sides which form the right angle are equal, as in the triangle A, the triangle is at the same time an "isosceles," and the two acute angles are equal one to the other, and each equal to the half of a right angle, or 45°.

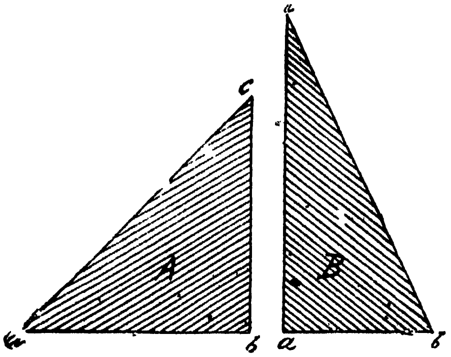


Fig. 68.

To construct an isosceles right-angled triangle, it is sufficient to have one of the two equal sides, and after having drawn a right angle, as *a b c* in A, fig. 68, and having given to its sides the given length, the triangle is described by joining the extremities of these two sides, as *a b*, *b c*, by drawing a third line which will be the hypothenuse, as *a c*. If the two sides which form the right angle are unequal, as *a b*, *a c*, in B, fig. 68, we give to each its proper length, and join their extremities, as *c* and *b*, by the hypothenuse *c b*. Another case is that in which we may only know the length of the hypothenuse, as *b c*, and one of the sides forming the right angle, as at *a b*. In this case, to describe the triangle, having drawn the right angle *a b c*, and given to one of the sides the given length, as *a b*, from the extremity of this side, as the part *a* in A, fig. 68, and with a radius equal to the length of the hypothenuse *a c*, describe an arc which will cut the second side, as *b c*, of the right angle in the point *c*. The point *c* of intersection will be the extremity of the second side, which must be joined to that of the first to form the triangle by the line *c a*.

THE FACTORY OR MILL HAND AS A TECHNICAL WORKER.

THE ORGANISATION, GENERAL DUTIES, AND SPECIAL WORK OF THE STAFF OF FACTORIES FOR THE PRODUCTION OF SPUN AND WOVEN GOODS—THAT IS, "YARN" AND "CLOTH"—AND THOSE CHIEFLY IN COTTON AND WOOL—GENERAL DESCRIPTION OF THE VARIOUS PROCESSES OF MANUFACTURE.

CHAPTER XI.

IN our description of the drawing frame given at the end of the last chapter, we stated that the upper rollers, *a, b, c* (see fig. 9, p. 148), are covered with leather, the lower rollers being grooved or fluted, as *d, e, f*. The upper rollers extend the length of the heads; they are also covered on the upper part by the saddles *v* and *w*, which are pressed down by weights. The doubled band goes through the funnel *f*, fig. 8, and the taking-off rollers *g*, into the coiling "can" *h*. This contrivance, already partly described when considering the "carding engine," which has for several years been almost universally used, is for the purpose of putting as much cotton as possible into the cylinder by equal pressure, and by coiling it evenly. A driving strap and toothed-wheel arrangements convey the motion to the taking-off rollers. These rollers take the band through an eccentric opening in a spiral disc, into the pot, whilst both parts are made to revolve by toothed wheels. The spiral coils of sliver have the diameter of the cylinder for their diameter, and as more cotton keeps coming into it, the pressure is increased. The machine is also fitted with a self-stopping motion placed before the rollers, and in newer ones also after them, so that if one of the bands breaks, the machine stops at once of its own accord.

For a long time endeavours have been made to get the greatest possible length of sliver into the coiling can, so that, having to change cans less frequently, much labour is spared. But the description of the newest inventions would take up too much space.

The Management of the Drawing Process and the Drawing Frame.

The top rollers of the drawing frame being covered with leather, dust or sand is liable to injure them, and to such an extent as would prove most detrimental to them for the work they have to perform. The drawing frame derives its name from the lengthening, extending, or drawing out of the fibres of the cotton by an arrangement of rollers. If a sliver is to pass through them, say six inches long when it enters the rollers, when it is delivered (*i.e.* passed through the rollers) it is about six times as long (thirty-six inches). The object of this drawing frame is, however, not simply that of lengthening the sliver, but also of equalising it. We shall now give a general description of its arrangement. The drawing frame in its mechanism is simple; the framework is also simple, but of a substantial character. It needs to be so, from the fact that the working parts of it are at the top of the frame. Our readers, we hope, will well consider the matter of regulating machinery according to the part where the working of it is distributed. Thinking out the principle of leverage will prevent us from making many mistakes. The first driving shaft is fixed at the lower part of the frame, as near to the floor as may be convenient, and the shaft runs the whole length of the frame. The frame varies in length according to the requirements of the user—*i.e.*, the amount of work which it is necessary should be produced. The drawing frame is divided into what are called "heads," some having three, others having four heads. Each head is divided into "deliveries." These terms give to the experienced man the size or capacity or amount of work the frames are capable of performing. We now define the various parts of this machine under the heads as referred to. We have said that the drawing frame is composed of three heads—that is, the length of it is divided into three equal parts, and each part of it is perfect of itself doing the same work as the neighbour heads. Each head has its own separate driving, and can be set to work or can be stopped independently of the other heads which are in the same frame. The driving shaft is, as we described, the length of the frame, and from this shaft each head is driven separately. When any breakages take place in any one of the heads, the other heads go on working as usual, but as one part of the frame depends upon the other for its work, it is expedient that all parts be kept at work. It is necessary that the frame should be so divided, on account of the system through which the processes require to go, so as to have the convenience of passing from the first head to the second head, and so on to the third. This arrangement is commonly preferred in medium and fine spinning mills. But in coarse spinning mills each head is a separate one of itself, and is driven separately. The amount of work which must be passed through is enormous. Where an arrangement for such work is required, they stand like the fingers on our hands when placed flat upon a table: *i.e.*, as a comparison, the first passing through the first finger, and the slivers dropping into a can, a series of cans are placed up to the second finger, passing through that, and then through the third in like manner. The female who attends to this frame has only to turn round from one to the other, to remove the drawn cotton, which is delivered into cans, in order that the slivers can be protected from any entanglement, and also for the convenience of being carried from one place to another by the tenter. Such frames are termed "single-headed drawings." Each of these heads is divided into two, three, four, five, or six deliveries. What is meant by the heads will now be well understood, and we therefore now pass on to the subdivisions of the heads, which are called "deliveries."

"Deliveries."

In all "drawings" the general rule is to run six ends through at the back part of the head, and they come out as one, being all put together: this is known as a "delivery." Each head, as we have said before, has its deliveries—maybe two, three, four, or more. The process of running the slivers through three or more heads has two objects. The first is to obtain parallelism of the fibres. This is of such importance that good yarn or thread cannot be made unless the fibres are lying side by side; for in this way they are so well arranged for twisting that stronger thread is produced. Nor is it only that a stronger thread is produced, but that it is much smoother, and thus more satisfactory when offered in the market. Were it not for this system of doubling and re-doubling to the extent of many thousands of doublings, and also the re-drawings, the fibres would lie in various directions, certainly far from parallel with each other. But by this continual drawing of the sliver, they are made to lie all in the same direction, and the result is worth all the labour and extra expense bestowed upon the working. The drawing frame has also another important duty to perform, and that is to bring about more evenness of sliver, and thus of the finished thread. Those accustomed to weigh the sliver as it leaves the carding engine are fully aware that by taking two yards in length each from half a dozen cards, the probability is that not more than two would be the same weight. Long practice in this particular convinces the experienced man that something must be done to equalise the slivers, so that as they advance in the process of doubling, more evenness in their fibres is obtained. Hence the value of the drawing frame. Six slivers are put up behind the frame, and on the opposite side it terminates in one; and then six of those are put behind another head, and they also terminate in one end; and so with the third head. This putting up of a series of slivers together in this manner intermixes the thick and thin ones, and the even ones come also in amongst them, not by any means to the detriment of the irregular fibres. This, it will be observed, is why so much doubling is requisite in the preparing of cotton thread. It makes the thread more level, and thus stronger. It is, as we have said, a very important machine, though the sliver as it leaves the last head, is just the same thickness as it was when it left the carding engine, notwithstanding it has been doubled three times over, with six ends at each time.

The Rollers—Their Importance—Practical Details connected with them.

We shall now describe the roller part—*i.e.*, the part of the drawing frame where the whole of the slivers are as they come from the carding engine, and are taken to it to pass through the rollers. Six cans full of sliver are taken to the drawing frame from the carding engine, and six slivers are then put up to the rollers to be drawn. The rollers are in number eight —*i.e.*, four under rollers (iron fluted), and four top rollers also of iron, but covered with a good close, firm cloth, made for the purpose, called "roller cloth." This is secured by first painting the roller, and when dry applying glue of a particularly tenacious character, to hold the cloth firm upon it. It is then covered with leather, sheep or lamb skin, which is prepared for the purpose. This being put tight on the woollen cloth, makes a very smooth surface. Nothing less than a smooth surface can be used for the purpose, as fibres of cotton are so subject to "lick," that is, adhere to the roller, and thus cause the sliver to run round it, and so make considerable waste, besides disarranging the sliver as it passes through. The top rollers run on the top of the others (the bottom rollers). The latter are driven by tooth and pinion, but the top rollers by friction from the bottom rollers. In order that the top rollers should be driven with certainty—*i.e.*, at a rate uniform with that of the bottom rollers—weights are attached to them, which cause the top leather rollers to move at the same velocity as that of the bottom rollers; the weights at each end of the roller shaft are suspended by links, which, as the term is often used in cotton mills, is for the purpose of making them "bite." This being done, the cotton slivers are put between the rollers. When the cotton has just passed between the rollers, attention is required to be given to a very important matter—*i.e.*, to ascertain if the rollers are at a proper distance from each other—and this is seen in a moment by a practical man. If they are not fixed at the proper distance for drawing, where a long draught is required, it is shown in two ways. First, if the rollers where the long draught is—*i.e.*, the two front rollers (called front when the drawing is finished)—are too far apart, the sliver will be unevenly drawn, having thick and thin places; this must be avoided in the drawing frame, or else the finished yarn will be much deteriorated in spinning value. Neglect in the working of this frame can never be fully repaired, although the sliver may come in contact with comparatively perfect drawing in all the other frames which follow—*i.e.*, the "slubbing," the "intermediate" (often termed the second slubbing), the "roving" and "finishing Jack" frame.

THE STONE MASON.

Designs for Crosses, Figs. 1—3; for "Finials," Figs. 4—6.

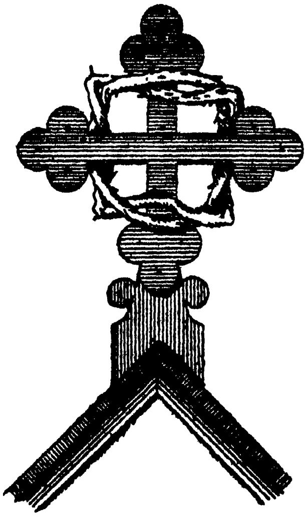
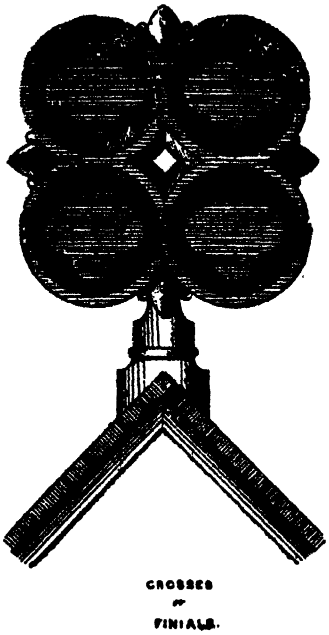


Fig. 1.



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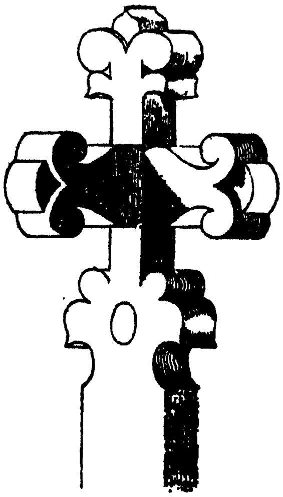

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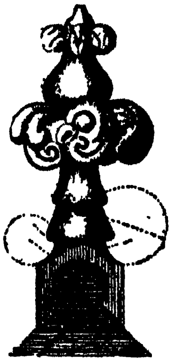

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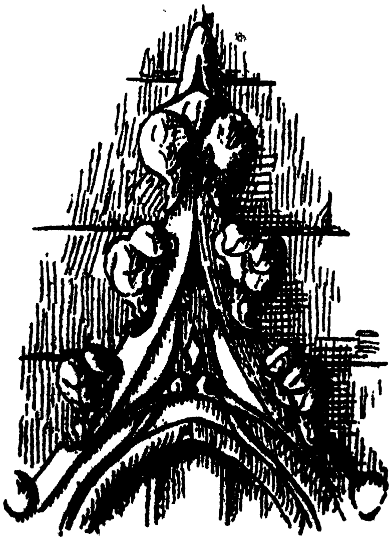


Fig. 5.

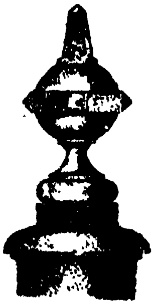


Fig. 6.

GREENHOUSE.

END ELEVATION.

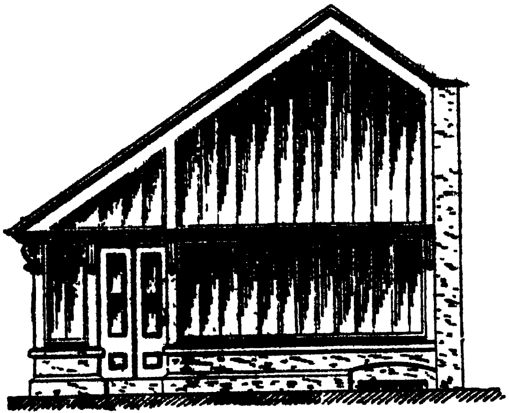


FIG. 1.

TRANSVERSE SECTION.

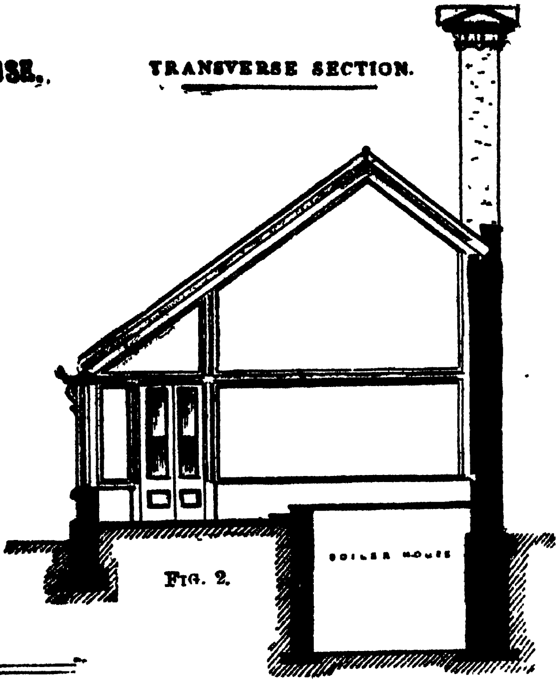
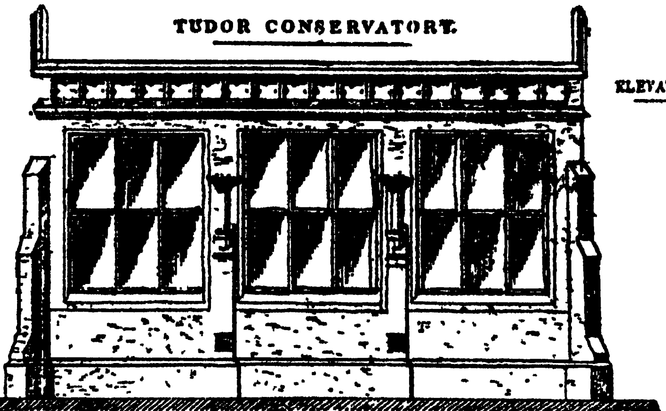


FIG. 2.

TUDOR CONSERVATORY.

SIDE ELEVATION.



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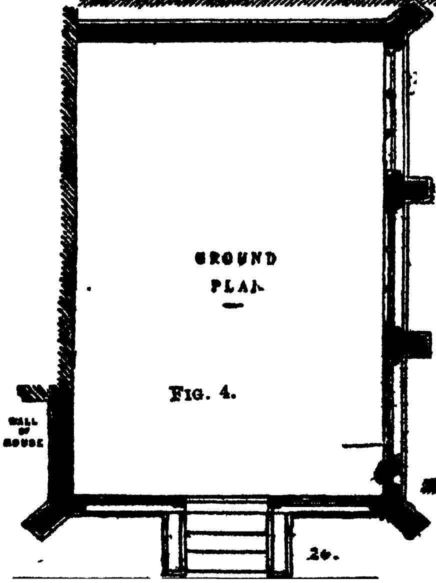


FIG. 4.

END ELEVATION

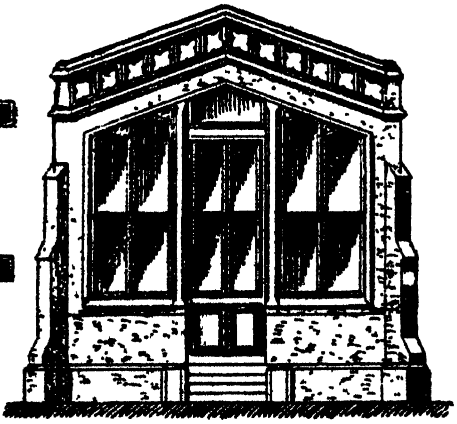


FIG. 5.

"THE STONE MASON" AND "THE JOINER."

For Gates, etc. Figs. 1, 2, Style—Domestic Gothic; Figs. 3, 4, Italian.

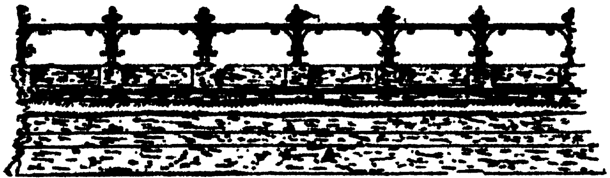
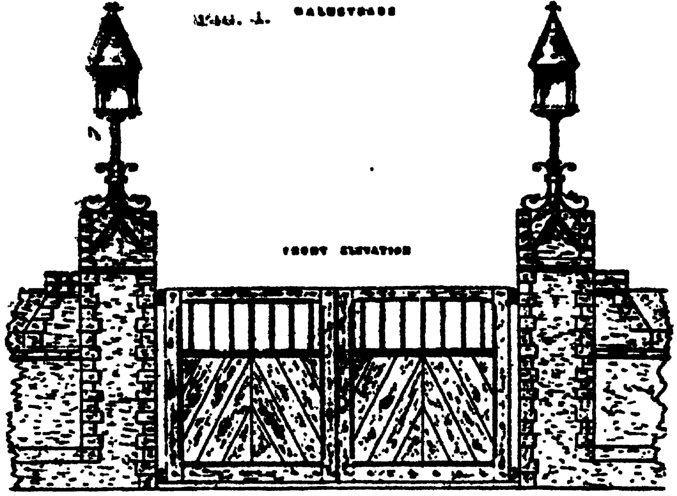


Fig. 1.



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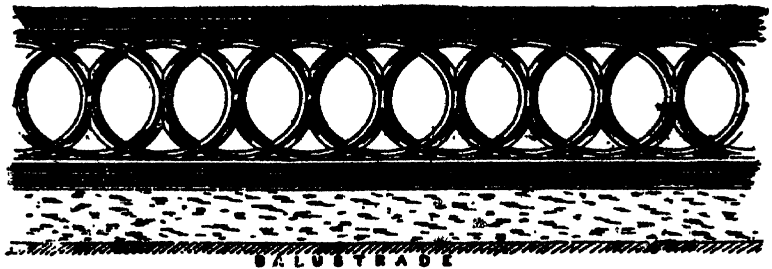


Fig. 3.

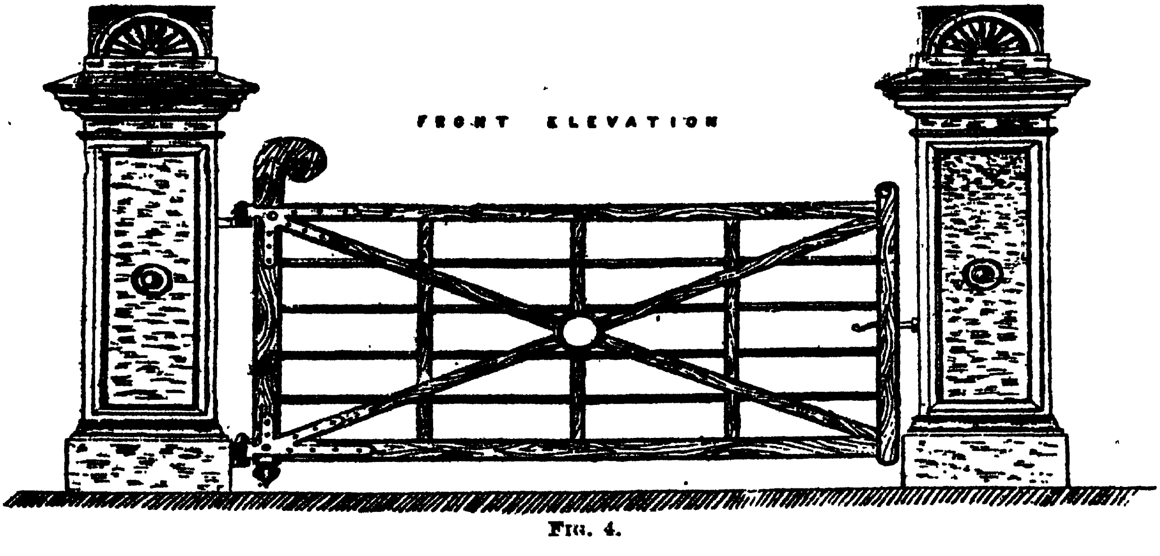
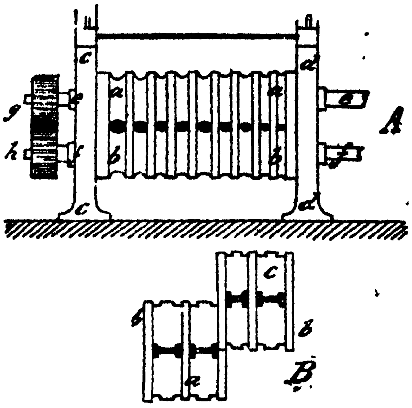


Fig. 4.

THE IRON MAKER (*see Text*).



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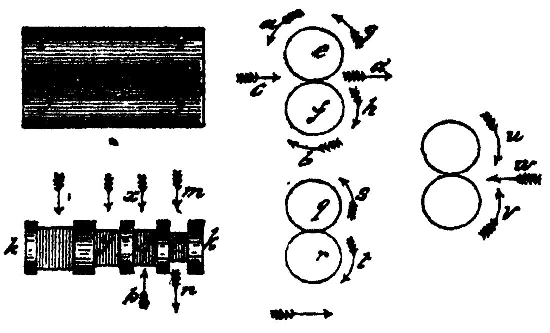

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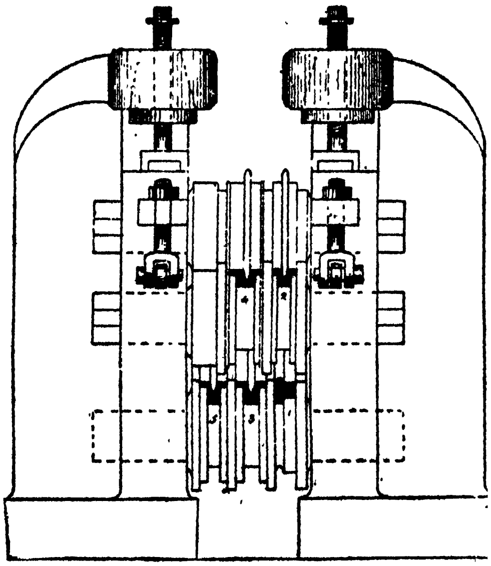

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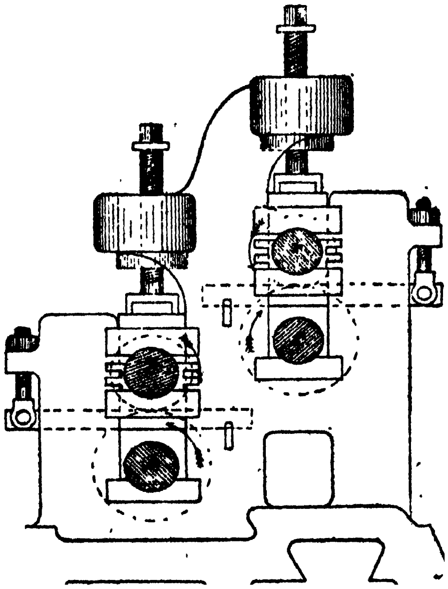
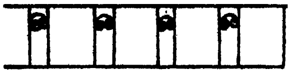


FIG. 4.

THE ORNAMENTAL WORKER IN WOOD AND STONE "MOULDINGS" (see Text).



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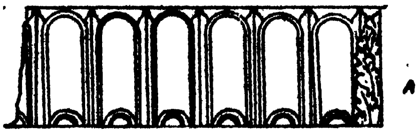

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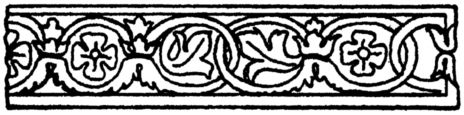

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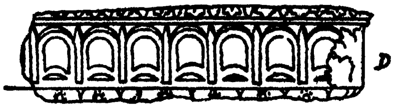

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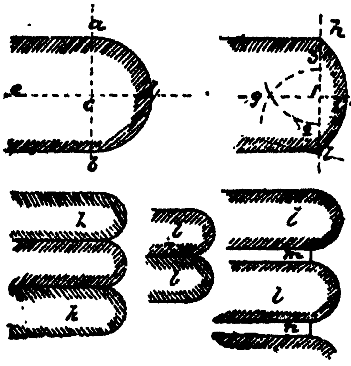

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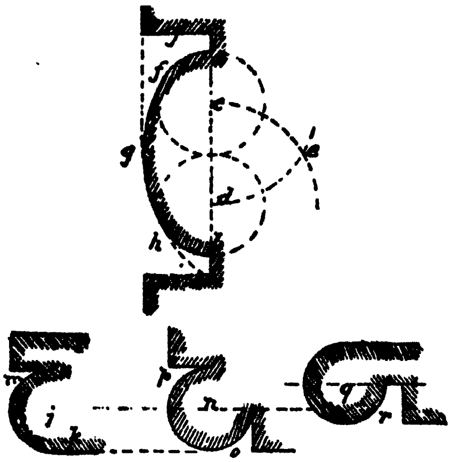

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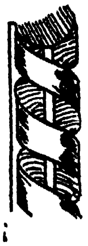

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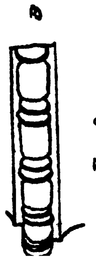

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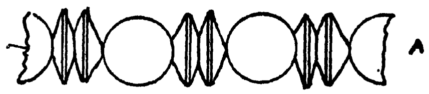

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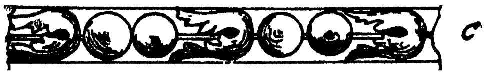

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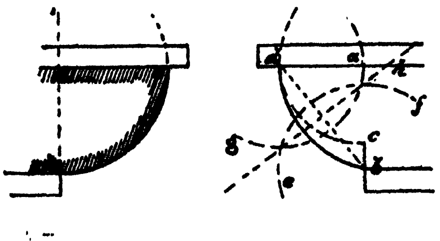

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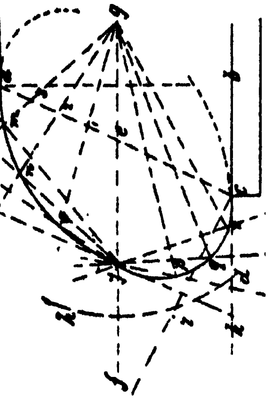

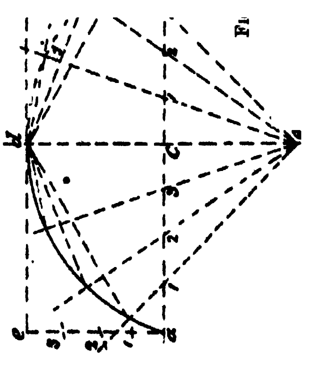

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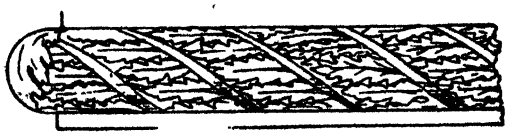

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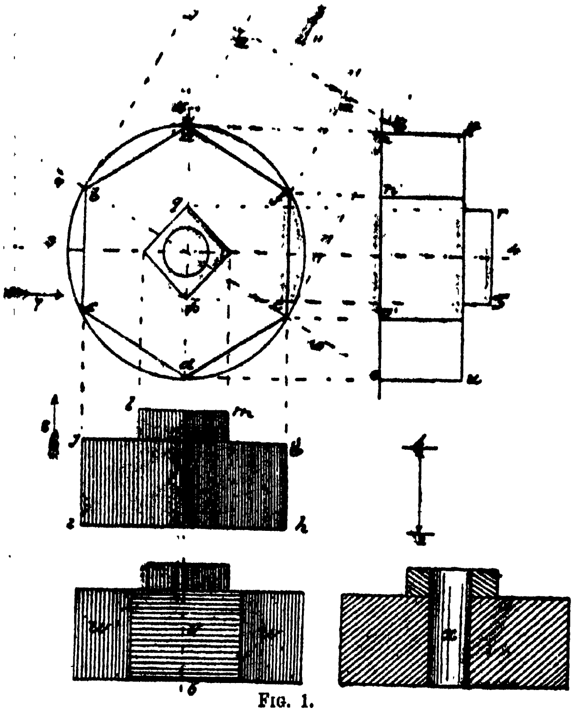

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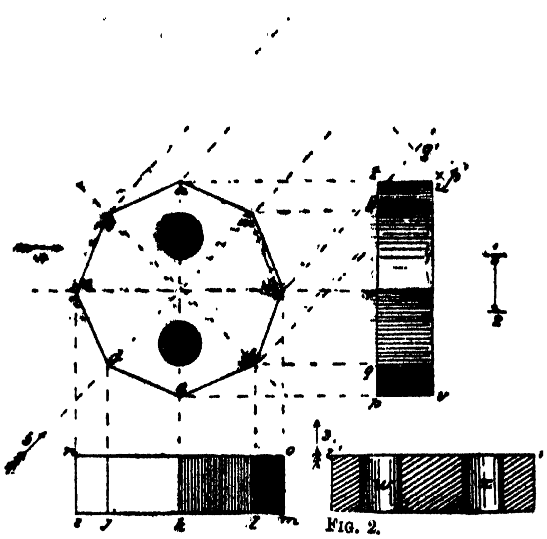

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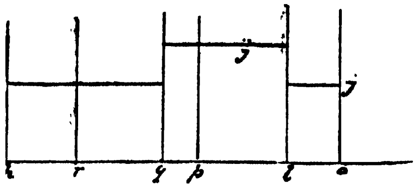

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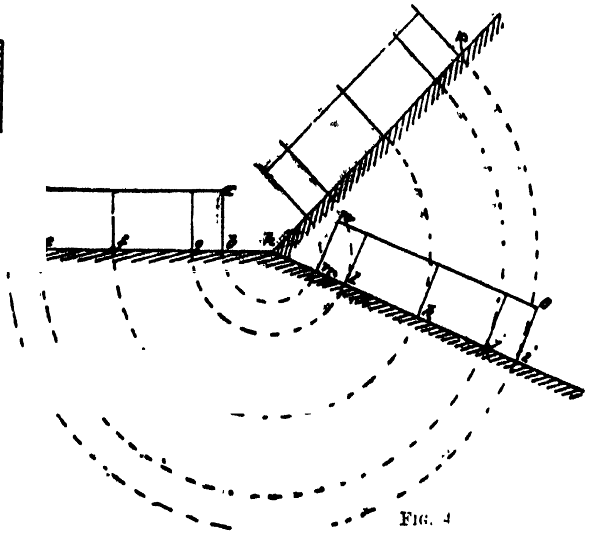

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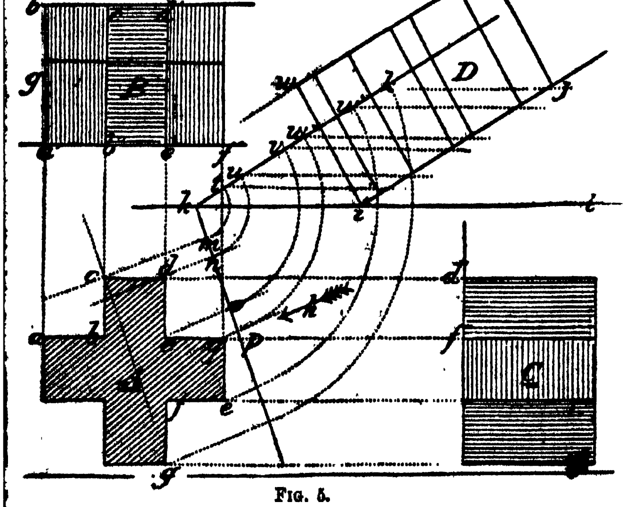

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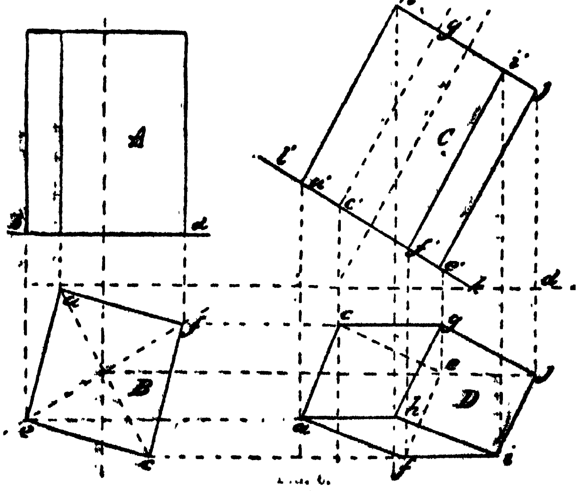
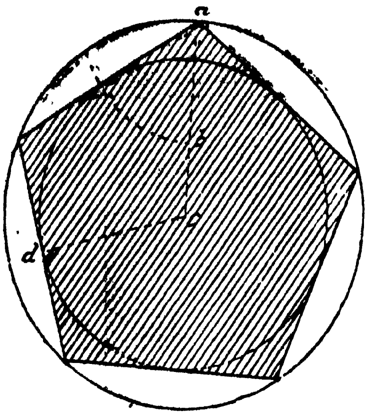


FIG. 6.

THE GEOMETRICAL DRAUGHTSMAN.



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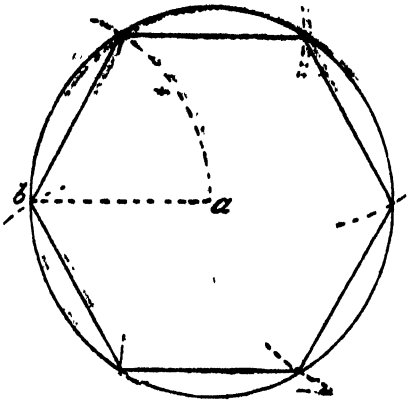

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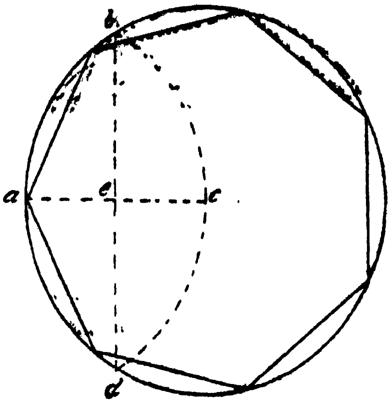

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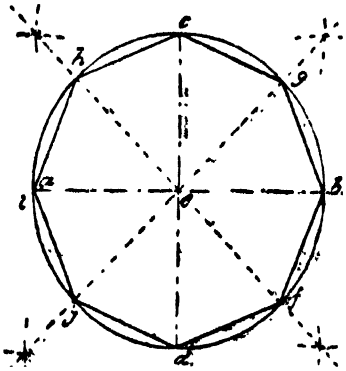

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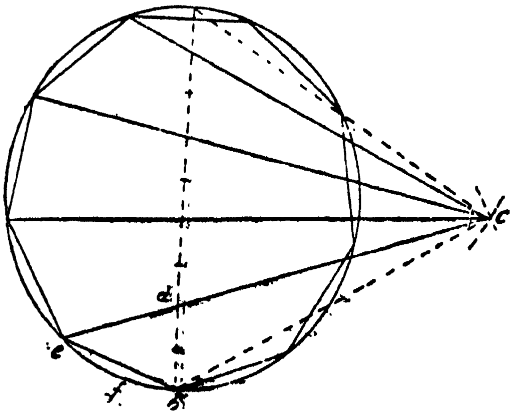


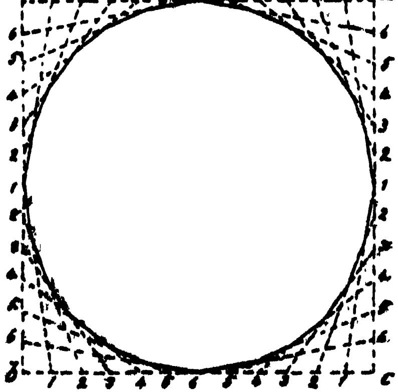


Fig. 6.

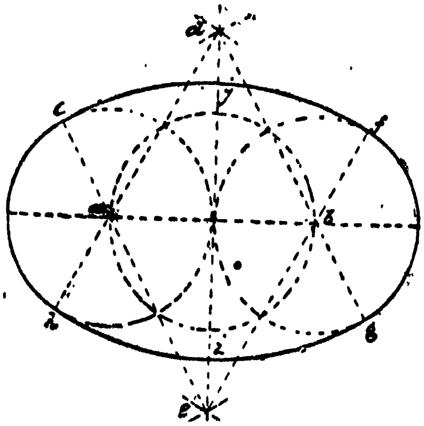


Fig. 7.

THE ORNAMENTAL WORKER IN WOOD AND STONE "MOULDINGS". (see Text).

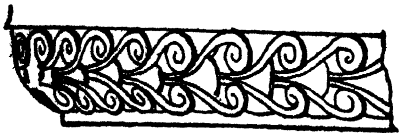


FIG. 1.

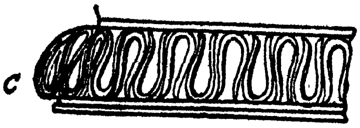
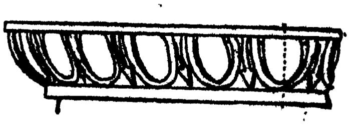


FIG. 2.



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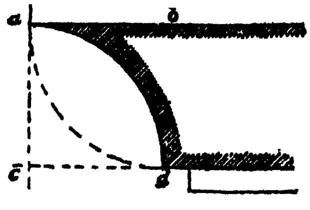

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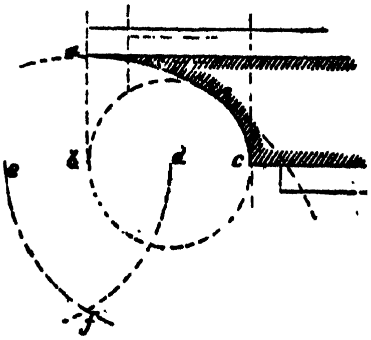

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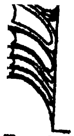

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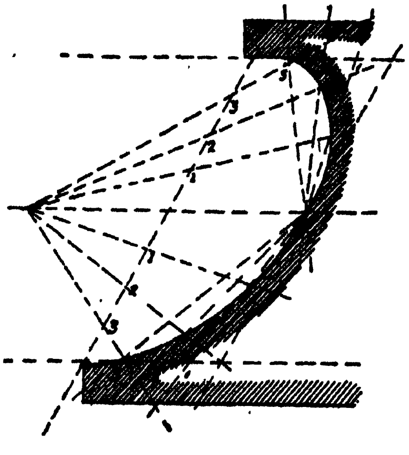


FIG. 6.

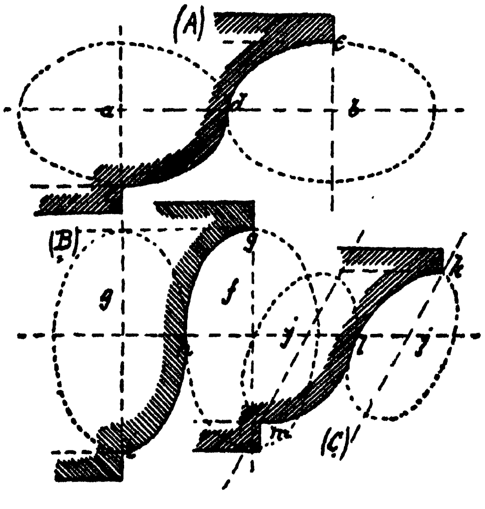


FIG. 9,

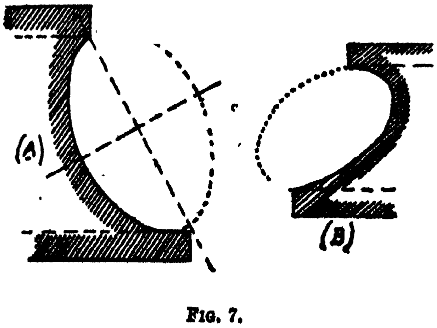


FIG. 7.

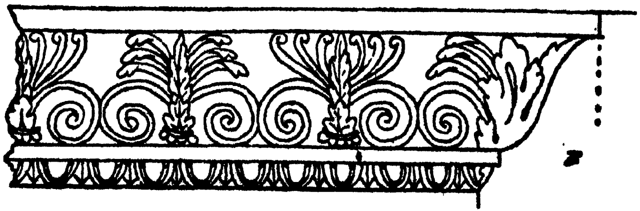


FIG. 10.

THE TECHNICAL STUDENT'S INTRODUCTION TO THE GENERAL PRINCIPLES OF MECHANICS.

LAWS AFFECTING NATURAL PHENOMENA—MATTER AND MOTION.

CHAPTER XXV.

In treating of action and reaction, at the end of preceding chapter, we noticed the phenomena attendant upon the throwing of a ball against a marble slab wetted on its surface, as exemplifying retarded motion through the action of repulsion. The flattening of the ball is the result of the compression of its particles, and this in proportion to the force with which it was propelled against the marble surface; and as this compression is proceeding, the repulsion of the particles of the ball increasing lessens gradually the motion of the ball in the direction of the force which propelled it, till it ultimately assumes a state of rest. The condition is now changed at this point, and we have in it an example of "accelerated motion" from the force of repulsion—for the two bodies are at their point of contact at the time above noticed in this highest degree or state of compression, acting or reacting on the ball—which projects it from the surface of the slab or back again in the same line of direction in which the force originally propelled or dashed the ball against the marble. We have in this accelerated return motion an example of the "recoil" or "rebound" of the ball from the marble. We can perceive that before the reaction or return motion takes place a certain time must elapse—that is, from the time the ball strikes to the time that its former motion is so retarded by repulsion that it stops. Now, the time taken in this process, which is represented practically by that of the ball in resuming its form, is clearly the measure of its elasticity; and the same holds true of all substances which are more or less elastic: the more elastic they are the quicker is the time in which they return to their original form; or, what is the same, the more quickly is their "rebound" or "recoil" made, and the greater is the extent or range of that in proportion to the force. It is this change in the form or the condition or position of the particles of a body which commences when it is put in forcible contact with another body that brings into play its own essential or inherent force of elasticity, which acts in direct opposition to the force which gives the contact or causes the concussion. The same phenomena, although expressed or shown in different ways, are illustrated by two or more elastic bodies in motion. Thus, if two ivory balls are propelled along a smooth and level surface with equal velocities and having equal masses, when they meet in the direction of their line of centres they will rebound or recoil from each other with the same velocity. In this case reaction and action are precisely equal. The same will be the case if the balls, though of same mass, meet each other or come into collision with different velocities or speeds: the recoil will be at different, but with exchanged velocities—that is, the ball which had the quickest speed at first will have the slowest speed in the recoil motion, and *vice versâ*. But action and reaction are still equal; for the accelerated motion of repulsion which comes into play when the retarded motion ceases—that is, when the inherent elastic force of the ball acts—will make the ball recoil in the same proportion. Hence it is that if there be an ivory or other perfectly elastic ball at rest upon a smooth level surface, and another ball of equal mass is propelled so that it comes in collision with the stationary ball in the direction of their line of centres, the stationary ball will dart or start off in the same direction as that of the striking ball, and with the same velocity which this possessed, while this in its turn loses its motion and comes to rest. In this transfer of motion reaction and action are precisely equal, for the force of reaction of the stationary ball acting in the way above explained in bringing the primary ivory ball to a state of rest—that is, annihilating its speed or motion—is the same as the force of action of the primary moving ball which gives the speed or motion to the ball which at first was stationary or at rest. This transference of motion from one elastic body to another, and which further illustrates the law of action and reaction equal and opposite, is seen in a row of balls which are in contact with each other and at rest on a smooth and level surface. If the ball nearest the source of force or power be struck by a ball propelled by that power in the same time as the line of centres of the stationary balls, the striking ball has its own motion arrested, or rather it is transferred to the first stationary ball; this transfers it to the second, and so on, till it is taken up by the last ball, which then darts or starts off in the same direction and with the same speed as the

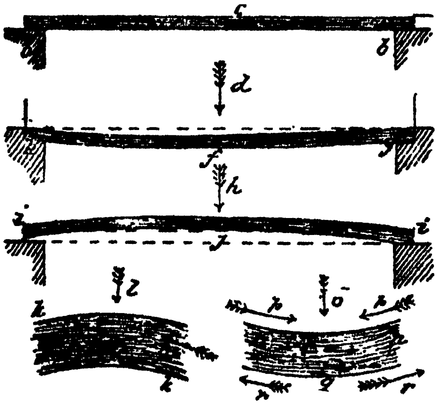


Fig. 20.

striking ball. If two balls coming in contact were of a perfectly non-elastic substance, there would, when the velocities and masses were equal, be no rebound or recoil, and therefore no motion, which would be destroyed, so that in coming into collision both would be at rest. While there is action there is no reaction, for there is no retarding force of repulsion causing a change in compression in the particles, so that there is no accelerating force or resumption of the parts, which would otherwise be experienced; and it is only by this inward change in bodies that their elastic force is measured, for if there is no change there is no elasticity. But, as we have said, there are no absolutely non-elastic bodies, so that we have many substances which, though not classed as perfectly elastic bodies, display the phenomena of elasticity to a greater or less degree. This elasticity in bodies coming or brought into contact with each other may be looked upon in the light of a spring placed between the two, which is capable of acting in two and in opposite directions. The reader will be able to understand the action if he supposes a spring to be connected with and projecting from a fixed and firm surface, as a wall, and to be of such a strength that he can press it inwards with but a moderate degree of strength of arm. As he continues to press inwards, he finds the speed—so to call it—get gradually slower and slower: this is the reduction of motion by the force of repulsion in the spring. But if, on reaching the point beyond which his strength in compressing the spring fails, he releases his muscular pressure upon the spring, he finds that its motion outwards increases very fast: this is the acceleration of motion arising from repulsion. We suppose in this case the spring to be very sensitive and acting through a wide range. A watch-spring is a good example: it takes a long time comparatively to wind up, so to say, or compress it into its spiral form, but on its being released by the fingers it springs outwards to its own condition almost instantaneously. If two springs attached to two bodies be brought into contact, and a force of some kind presses the bodies together, the spring will be compressed with a gradually retarding motion; and when the force is released or ceases to be exerted the springs will be, so to say, suspended in their forward movement, and the two bodies will then move away from each other. A very simple yet effective illustration of elasticity, as being as it were springs between the bodies, is obtained by holding two balls of vulcanised indiarubber between the thumb and finger and alternately compressing and releasing them, when they will alternately go towards and move from each other.

Springiness or Elasticity in Bodies.

This springiness or elasticity in bodies it is which, in virtue of the law we have explained, affects work done when bodies are to be forced into and through other bodies or be broken up or smashed. The more closely the bodies approach the condition of perfect elasticity—in the conventional sense of the term—the more difficult it is to break them up; and, if not only the body to be broken, but an instrument or implement by which the breaking is to be done, be elastic, the breaking up will be a matter of some difficulty. If both are equally hard, and as nearly as possible approaching the condition of absolute or perfect hardness, the result will be, possibly, that the smashing up of the two bodies—although in certain conditions the motion or force would, be so to say, counterbalanced, as in the case of the two meeting balls already explained—being absorbed, so to say, or taken up equally by the two bodies, but not given out by them, as they are destitute of elasticity. In the driving in of a timber stake into the soil, progression or downward movement is due partly to the elasticity of the timber, and partly to a certain degree of elasticity in the hammer: if both were absolutely hard and inelastic there would be no descent of the stake into the ground. For points connected with the work of of "striking" see paragraphs on the subjects of centres of gravity and centres of percussion.

Recoil or Rebound of Bodies.

We have seen that an elastic body or an ivory ball striking against a marble slab or an elastic surface recoils or rebounds from the surface, and the speed or velocity with which it does so is the same as that which it possessed at the instant of striking the surface. If the reader has traced the law of retarded and accelerated motion of repulsion as we have explained it he will have no difficulty in seeing this. The rebound or recoil of the ball or body from the surface is in the same line of direction as that exerted by the force. Thus, if the ball *a*, fig. 21, is made to strike the surface *b b* by a force acting in the direction of arrow *c*, at right angles to *b b*, the ball recoils or rebounds in the opposite direction, as shown at *c*, in order to avoid confusion with point *d*, but the direction of its path, *e f*, is the same as that of *c d*—that is, at right angles to *b b*—and takes the ball to *g*. But if the direction of the force acting upon the ball *h* be not, as before, from *m* to *j*, but at an angle to this, as in the direction of the arrow *h*, the ball *i* on striking the surface at *j* does not, as some at first sight might suppose it would, return to the point *h* in the same direct line *j i*, but it recoils or rebounds from the surface *j* in the direction *j k*, and reaches *l*, the line *j l* being in relation to the line *i j* identical with the line *j l*—that is, the angle of the force line *h j* is equal to the angle of recoil line *j l*. The usual form in which this law of "reflected" bodies is expressed is that the angle of incidence (as *i j*) is equal to the angle of reflection (*j l*). The term "incidence," here used to denote the angle in which the force acts which propels the ball or body, is derived from the Latin word *incidus*, and this from two Latin words, *in*, and *cadere*, to fall. A ray of light, for example, is said to fall upon a reflecting surface. In common language, the ball *i* in fig. 21 would not be said to fall upon the surface *j* in the same sense as the ball *a* falls upon *b b*, the distance *a d* being the extent of drop, but *i* is said to be "driven up" against *j* in the direction of *i j*, thus conveying the idea that force is applied, and not merely that of gravity, as in the case of a ball *a*. So that the popular expression is more accurate than the scientific one of incidence. The angle of "projection" would be a more accurate term, and would convey the idea of a force being employed, as that of the act of "throwing," the term "projection" being derived from the Latin *projicere*, *projectum*, and these from *pro*, for or from, and *jacere*, to throw from, or cast out. The meaning of the term projectile is thus clearly indicated by the derivation; and hence also, we think, the greater accuracy of the term "angle of projection." The term "reflection," in the other part of the definition of the law regulating the striking of bodies upon surfaces, is derived from the Latin noun *reflexio*, and this from *re*, from, and *flectere*, to bend, which gives in the term reflection a very clear idea of the change of direction.

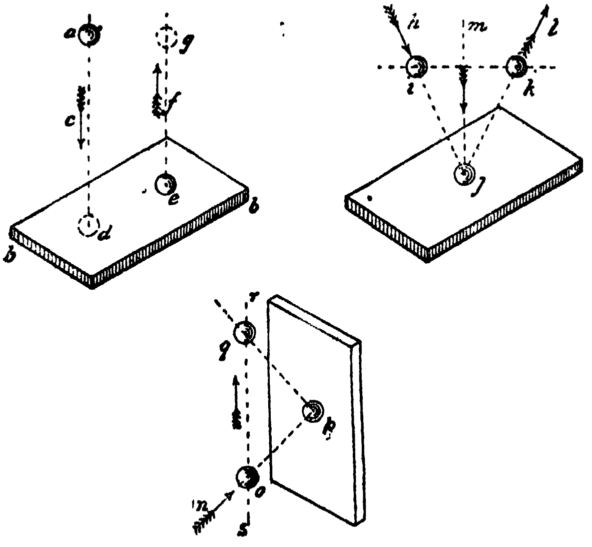


Fig 21.

Angles of Incidence and Reflection Equal.

This law of the angles of incidence (projection) and reflection being always equal is that which governs the phenomena of all bodies reflected, not only gas or air, but water as in waves, or light and sound as in solid bodies or balls. Much if not all of the skill in billiard playing in its highest ranges is displayed in taking advantage of this law, although there are players by the score who exemplify it in the most marvellous manner without the faintest conception that they are illustrating a very important law in physics. There are many who call it a scientific game who could not easily, if at all, explain on what scientific laws it depended. Every stroke illustrates a law:—In simple repulsion, if a ball is made to strike the ball *o*, fig. 21, with a blow or impact in the direction of the arrow *n*, one angle being equal to the other, and the ball, in place of driving *o* straight on, has to drive it in the direction of the arrow *p*, the stroke must be made in the direction of the arrow *n*, so that the angle at which the ball strikes the cushion at the point *p*—the angle *o p*—shall be equal to the angle *p q*, the ball rebounding from the cushion at point *p* and driving it along in the direction of *p q*. We have said that this law of angle of projection being equal to the angle of reflection governs the action of all reflected bodies—light, sound, water, and gaseous fluids or air alike; and it is this which is taken advantage of in a great variety of ways by those engaged in the various departments of construction. The following example well illustrates the action of the law as regards air. We suppose a candle to be covered by a transparent shade, and placed so high that the attendant could not reach to blow the candle out, from the shade intervening; but if he held a piece of paper or thin board, or even placed his extended palm in an angular direction, the blast of air from his mouth placed at a low level, although proceeding in such a direction that without the card it would pass far above and away from the candle, yet with the card is reflected from it in a direction such that it strikes the flame, and if the blast be strong enough extinguishes it—the angle of the blast of air passing upwards from the mouth to the card being equal to the angle of current of air from the card down through the opening of shade to the candle. This principle is exemplified in a very practical way in much of the apparatus of the ventilating engineer. The majority of his appliances, by which he creates currents or assists those created in ventilating tubes, by what are known as "caps" or "cowls," or more generally as "ventilators," depend upon the nature of the deflecting ("bending from"—see derivation of word "reflection") surfaces, as they are termed, given to them. The well-known engineer Tredgold was the first, many years ago, to show the value of deflecting surfaces in creating and assisting currents in ventilating tubes. Let us suppose a vertical tube or shaft up which a current of air represented by the arrow *a*, fig. 22, is issuing. The ascensional or rising force of this will be dependent *per se* upon the difference there is between the temperature of the air within the tube and that of the external atmosphere. The higher this is in the current, the quicker is its ascent. But there may be but a comparatively trifling difference between the temperatures of the air within and without the tube or shaft; in which case the force represented by the velocity of the current within the tube may be very trifling—not sufficient to withdraw its contents and deliver them to the external atmosphere at the upper part of the tube, as at *b*, quickly enough for the purpose required. Any external current, as a breeze of wind blowing across the mouth, as in the direction of the arrow *c*, by virtue of another law—that of friction or induction—"draws," to use the popular expression, a current of air along with it. So that the action of the horizontal current, as *c*, blowing across the mouth *b* of that shaft *a*, tends to draw, or, as popularly termed, "suck" the air out of the tube *a*, and thus tends to increase the velocity of the upward current in the shaft. But the wind or breeze, as it passes over the mouth *b* of the shaft, may be deflected, as at *d*, and blow down the shaft, and the force of the wind outside may be greater than the ascensional or upward current inside the tube; so that its withdrawing or ventilating action will be reversed. By making the top with bevelled edges, as at *e e*, the air is not blown down the shaft, as at *d*, but is deflected or bent upwards, as at *f*, and passing along by *g* across the open mouth, draws the air in it along, and thus aids the upward current in *h*, which may be naturally due to it. And if *i* represents the air entering the shaft at its lower part, it draws along with it currents, as *j*, *j*, from all sides. Tredgold's ventilating cap is illustrated in diagram *a b*, fig. 23, *c c* being the deflecting edge, *d d* that of the upper part of cap, and which, in the form given below at *c c*, is of the same diameter as at the lower part of the shaft at *a*. A cap or cover, *e*, is supported by vertical rods at some distance above the mouth *d*, to prevent rain and snow descending the shaft *a*. The best form for this cap is cylindrical, giving a circular edge all round to the deflecting part *d*. When the cap is of considerable height, and is made square, the sides are provided with deflecting plates, as at *k k*, fig. 21. A most efficient cap with deflecting surfaces, as shown in horizontal section at *f g g*, fig. 23: *f* is the orifice of shaft, the air ascending which passes out at the side opening at *g g*, and in calm weather rises vertically and escapes at the top of the cap, but in windy and breezy weather, the air blowing as from *k* (arrow to the right) is deflected right and left by the angular shield at *g g*, and is blown through and out at the opposite side. Angular shields, *h* and *j*, cover the opening *g g* at the side, so that they are protected from winds blowing as from *i*. In badly constructed shafts or chimneys the higher the wind blows the greater is the likelihood of down currents being created in the shaft, as at *d*, fig. 21; but in the case of a shaft the upper connection of which is provided with deflecting shields, as say at *g g*, *h j*, fig. 23, the fiercer the wind blows the more quickly is it deflected from the shields, and passing the surfaces, the more rapidly is the air withdrawn from the shaft—in other words, its ventilating power is increased. If the young reader made and fitted up a small model of such a cap, as at *f g g*, or as at *a b*, fig. 23, he would learn some useful lessons on the value of deflecting surfaces. Every one knows how the upper part of chimney stalks of factories are rendered still more unsightly than from lack of architectural effects they almost always are; and this extra ugliness arises from the smoke blackened brickwork. In windy weather the smoke is beaten down, and may be seen clinging, so to say, to the chimney for a considerable distance down the shaft. This is almost certain to be the case if the chimney top be finished so that its upper surface is flat, as at *t* in fig. 23; but by making the top with bevelled or sloping sides or edges, as at *u u*, the wind is deflected upwards and blown across and away from the chimney stalk. If this be carefully done, not only is the smoke prevented from being blown down and defacing the chimney stalk near the top, but the "draught" of the chimney stalk is greatly increased. Mr. Carmichael, in a very able paper on the "Construction of Factory Chimneys," read before the Society of Engineers of Scotland, amongst many points of great importance, pointed out the necessity of engineers paying more attention to the finishing of their caps or tops than was generally paid. This part, indeed, may be said to be generally neglected, as a matter of no moment.

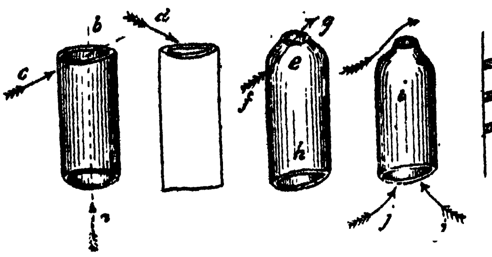


Fig. 22.

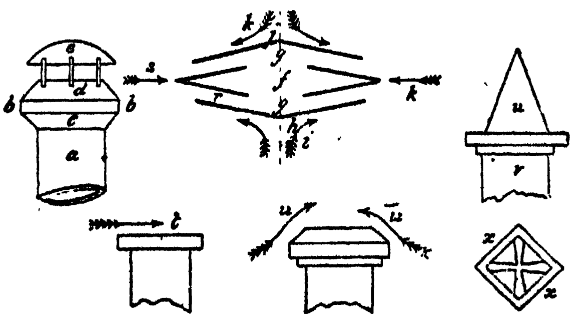


Fig. 23.

THE IRON MAKER.

THE DETAILS OF HIS WORK AND THE PRINCIPLES OF ITS PROCESSES.

CHAPTER IX.

Point of Fusion of the Ore in the Blast Furnace.

CONSIDERABLE diversity of opinion has existed as to what is the exact position of the point of fusion of the ore in the blast furnace. It is obvious that this must be largely a matter of conjecture, in common with other points connected with the action of the blast furnace. Its sides are not like those of a glass case, through which the various actions and results can be seen and determined upon with accuracy. Nevertheless, while we are kept from seeing what those actions are, it must be recollected that so accurately are the various stages of chemical combinations known by scientific men, that of many, certainly of some of them, it can be predicted with safety that these results are so-and-so. Chemists know that certain combinations must in certain circumstances take place, but it does not follow that they can trace out or define the exact positions in time or space assumed by the substances as they form the combination. The very condition of the blast furnace points out, indeed, that there must be some points at which we can only guess or conjecture what is going on there.

It was formerly the generally accepted opinion that fusion in the blast furnace should take place in the space in front of the *tuyères*; now, however, authorities on the subject seem to regard this view as entirely erroneous. The blast furnace may be considered as a fire supplied with fuel and ore by means of a perpendicular tube placed directly above the fireplace, the infusible fuel separating from ore and flux and coming to the top. It seems more correct to represent the zone of fusion, not in the zone before the *tuyères*, but at a considerable height above them, and at a distance from the soles equal to half again as great as the distance above the *tuyères*.

We see from the foregoing statements and diagram that when the ore has reached a certain point or zone in its downward course in the furnace, it becomes by the process of reduction a mass of what is called spongy iron. In the primitive methods of making iron elsewhere referred to in this paper, when the ores used were only of the richest, this spongy iron was very nearly iron in a state of purity, so that it could be and was withdrawn from the furnace then used—not the blast furnace as now used, which was the invention of a very much later date, coming down to our own times—as good malleable iron, and, as we have seen, sometimes steel, although the fact that this was the actual product was not always and certainly known to them. But in the working of the modern blast furnace, such is the low percentage of metallic iron and such the high proportion of debasing constituents or impurities, that the ore when it reaches the spongy stage of reduction is very far from being pure iron.

Power of the Spongy Iron to take up Debasing Constituents of the Ore—Phosphorus.

In this spongy state the iron is peculiarly active as an absorbing medium; it takes up or absorbs, therefore, while in this state, certain constituents, the majority of which are what are called by metallurgists debasing constituents, as tending to deteriorate, in proportion as they are present in it, the constructive or practical value of the iron ultimately obtained or withdrawn from the furnace. Of these debasing elements absorbed by the metal when it reaches that zone of the furnace in which we have seen that it becomes what is called spongy iron, the worst are the sulphur and the phosphorus. The last named of these two is present in some ores—as in those of the Cleveland district, already named—in such high proportion that the metal or iron produced from them stands by itself very low on the list of constructive irons. The presence of phosphorus brings about that condition in the metal which is very antagonistic to the constructive strength of iron and to the easy facility with which it may be worked when in the condition known as wrought iron. This quality given by the presence of phosphorus in wrought iron to the metal is known as "cold short"—that is, the characteristic which tends to make the iron brittle when cold. It will be seen, therefore, that the presence of phosphorus in steel, more especially in those high qualities of it used for cutting implements, is quite destructive of its utility for such purposes; hence the absolute necessity to get rid of the phosphorus in steel used for cutting instruments. Phosphorus in iron constitutes also one of the greatest difficulties with which the steel maker has to contend. (See the series of papers entitled "The Steel Maker.") For long its too abundant presence in the metals with which Mr. (now Sir Henry) Bessemer dealt in his first attempt to produce what is now known as "mild steel," baffled all his endeavours; and such were the difficulties it presented to him that at one time it seemed but too certain that his process, with all its great promise, would add another to the long list of unsuccessful discoveries or inventions.

The spongy iron, active as we have seen in its absorptive tendencies, takes up the phosphorus which is derived from one of the organic constituents of the ore. "The phosphoric acid," says Mr. W. M. Williams, "of the phosphate of lime is dissociated and reduced, the lime probably combining with some of the silicic acid and the phosphorus acting with the iron directly." All our fuels, or the majority at least of them, contain phosphates, as do by far the greater proportion of the ores the iron master has at his command. The process of intense combustion going on in the interior of the blast furnace reduces these phosphates—the work done by the furnace being throughout one of what is technically called "reduction," and the whole of the resulting phosphorus is absorbed by the spongy iron. The properties of this debasing element present in the irons as produced by the blast furnace, and from which, as we have seen, the two higher and ultimate forms of wrought iron and steel are produced, varies, as may be gathered from what we have already given on the subject of ores, very much according to circumstances, being present in some ores to as high a proportion as 3 per cent., down to as low as a mere "trace," this term indicating that the amount or quality present is so small that no value which can be stated in figures is attachable to it. Phosphorus being an element so productive of evil, as deteriorating or lowering the constructive value of iron, it is scarcely necessary to say that for long the endeavour of metallurgists, both practicians and chemists, to get rid of it, or to eliminate it from our ores, formed a most striking feature of the art and science of iron making. This desire was all the more intensified, and the endeavours made by metallurgists rendered all the more earnest, when the new era of iron working commenced, under the auspices of Bessemer and Siemens, whose processes, by producing mild steel in such enormous quantities and with such ease as compared with the old methods, revolutionised the trade, as the reader will find fully detailed in the companion paper to this, entitled "The Steel Maker." For, as we have seen, the presence of phosphorus in iron presented one of the greatest difficulties in the new processes of steel making. How the difficulty was got over the reader will find explained in the paper on steel making above alluded to. But the method adopted did not in reality touch or at least bring about that elimination of the debasing element of phosphorus which, as we have just stated, was what metallurgists were so anxious to accomplish. This department of iron making progress will be found fully explained in "The Steel Maker": suffice it here to say, that of all the methods proposed to dephosphorise and desulphurise iron ores, none has been so eminently successful in practice as that known from the name of the two discoverers or inventors as the "Thomas-Gilchrist" process.

Action of the Spongy Iron in the Blast Furnace in taking up Debasing Constituents (*continued*)—Sulphur.

From the second term just used in connection with the dephosphorisation of iron the reader will perceive that sulphur is another and in some instances a seriously debasing constituent of iron. The sulphur taken up or absorbed by the mass of spongy iron present in its zone of the furnace is derived chiefly from the sulphur present in the iron pyrites in the fuel, and this even in the case of the highest class of coke. Sulphur is also derived from the bisulphide of iron, which is an impurity very generally met with in iron. The sulphur, however, can, as a debasing element, be largely reduced, or rather prevented from being absorbed by the spongy iron, by certain methods of blast furnace working, of which the chief feature is the use of the flux in excess, and keeping the hardest of iron to the class known as the grey variety, and which is the best cast iron. The different classes of iron produced in the blast furnace will presently be given. The way in which sulphur acts as a debasing constituent in iron is by giving it a tendency—known as "red short"—to brittleness when red hot—that is, in the case of wrought iron, the condition in which the iron is when being forged or worked into the various forms used in the constructive arts. This is evidently a serious defect; and although by certain styles of blast furnace management much of the sulphur present in the metal can be eliminated, still the necessity for a more direct method of getting rid of it has caused many efforts to be made to secure it. The process of Thomas and Gilchrist aims at desulphurising as well as dephosphorising iron ores, although possibly it is of more value from its latter characteristic than from the former. We thus see that these two debasing constituents give opposite characteristics to the metals.

Action of the Spongy Irons in taking up Debasing Constituents (*continued*)—Silicon and Manganese.

In addition to the two debasing constituents of iron now named (phosphorus and sulphur) the spongy iron takes up or absorbs two others—namely, silicon and manganese. These do not, however, rank so high as deteriorating elements as the phosphorus and the sulphur; still they are debasing elements, and have therefore to be got rid of as much as possible. Of the two silicon is generally esteemed the worse in its effects; but Dr. Siemens has shown that the presence of manganese in steel is productive of deteriorating influences upon its constructive value. The silica in iron is derived from the various earthy impurities present in greater or less proportion in all iron ores; these earthy impurities are chiefly clay and quartz, present generally in the form of silicates. But these impurities are also present in the fuel used for reduction, whether that be in the form of coal in its raw or natural state, or in that of coke in what may be called its manufactured condition. Now, these earthy impurities are fused or melted with such difficulty, even under the high temperature present in the blast furnace, that they are considered practically to be infusible. Hence the employment in the blast furnace of a material which, by entering into combination with the earthy impurities, changes them into substances which are capable of being smelted or made fusible to a considerable extent. This material is the "flux," which, as we have seen, is universally lime. The lime, combining with the earthy impurities—chiefly, as we have seen, clay and quartz—forms the silicate of lime and the silicate of alumina, these being fused into a species of "lime glass," otherwise and popularly known as "slag." The particles of the "spongy iron," at that zone of the blast furnace which we are now considering, take up mechanically, or become more or less coated or covered with this slag, or fusible and fused "glassy silicates." And their silicic acid being more or less reduced by the high temperature present at the zone of the blast furnace at which the "spongy iron" is formed, a proportion, greater or less according to circumstances, of the "silicon" is absorbed by the iron, the silica being decomposed when in contact with iron. All iron ores do not contain "manganese," but many do; and if any is present in the iron produced in the blast furnace, a portion of it will be absorbed by the spongy iron.

We have so far traced the process of reduction of iron ores in the interior of the blast furnace; and we have arrived at the result that, at a particular zone of the furnace, and which we have indicated in the diagram in fig. 1, Plate CLXVII, and in connection with it have fully described, we obtain iron in a partially fused condition, and possessing such mechanical or physical characteristics as to give it the name of "spongy iron." But, so far from this being a pure metallic iron, it is an iron more or less debased by impurities, the ores used being, in practice, so far from pure oxides of iron, that they are mixed up with a variety of impurities, which are added to by those present also in the reducing agent—that is, the fuel, coal or coke, as the case may be. In place, therefore, of having a mass of pure iron at the zone of the blast furnace now under consideration, we have, in fact, only an alloy, in which the percentage as well as the peculiarities of the alloying substances vary according to circumstances. This zone, at which the iron is found in the stage or condition of spongy iron, may be called the "absorbing zone," as it is here that the iron absorbs or takes up the constituents we have named—phosphorus, sulphur, silica, and manganese. Other ingredients or constituents, present in many ores, are also taken up or absorbed by the iron; but these are either in such minute quantities, or are not very powerful as debasing constituents tending much to deteriorate the value of the resulting iron, that metallurgists do not take them into account as a practical and general rule. The proportions or percentages of the constituents we have named, which are practically considered as the debasing constituents of the iron, vary much according to circumstances. Thus, of phosphorus, the cast iron produced in the blast furnace may vary from what analysts call a "mere trace," or "a trace," up to as much as 3 per cent., and even more than this. Sulphur, as we have seen, may by the style of working the process of reduction in the blast furnace, be largely eliminated from the ore or metal, but may be present up to as high a proportion as 1 per cent. As regards silica, it has this peculiarity—which distinguishes it from the other debasing constituents—that it often reaches a very high percentage indeed, as much as from one-sixth to nearly one-fifth of the mass. The average may be taken at from about 2 to nearly or even over 4 per cent. The proportion of manganese in iron varies very much, and is usually low.

Further Action of the Spongy Iron in the Blast Furnace—Carbon.

But at the zone of spongy iron, or what we have called the absorbing zone of the blast furnace, another element is taken up by the spongy iron; and this is an important one—namely, carbon. This, however, is done in such a particular way that it has given rise to a term which indicates its characteristic—namely, "carbon deposition." This shows that it is not so much a process of absorption of the carbon by the spongy iron, but rather that it is mechanically placed or deposited upon the surface of the granules of the iron. This is, in fact, what is the result of the process; although it is understood or held by authorities that some of the carbon is actually absorbed by or combines with the iron. This action or deposition of carbon upon the particles of the spongy iron, at the zone of absorption, owes its discovery to the laborious and patient research of Mr. (now Sir I.) Lowthian Bell. We have already named this gentleman, whose reputation is world-wide, as the great authority on the action of the blast furnace, and to his elaborate series of papers on the subject, as published in the pages of the Journal of "The Iron and Steel Institute," we have directed the attention of the reader as to a mine from which can be extracted everything that is worth knowing in connection with this important department of practical metallurgy. This action or deposition of carbon is due to or arises from the principle of the "dissociation" of chemical compounds by the agency of high temperatures, and is such that it gives to the oxide of iron—which, however, as shown by an eminent Continental chemist, must always have present with it protoxide of iron—the power of "splitting up" the carbonic oxide (present in such large volumes, as we have shown in a preceding paragraph on the interior of the blast furnace) into carbon and carbonic acid ($2\,CO = C + CO^2$).

THE GRAZIER AND CATTLE BREEDER AND FEEDER.

THE TECHNICAL POINTS CONNECTED WITH THE VARIETIES OR BREEDS OF CATTLE—THEIR BREEDING, REARING, FEEDING, AND GENERAL MANAGEMENT FOR THE PRODUCTION OF BUTCHERS' MEAT AND OF DAIRY PRODUCE.

CHAPTER XX.

AT the end of last chapter we stated that two oxen of the same breed might show very different capacities for fattening—one feeding slowly, the other quickly. Nor does the animal disposed to fatten quickly take always the largest amount of food; for, just as we find amongst men, a stout man, who might be supposed naturally to require a large amount of food merely to keep up his frame, is found to take less food than a spare one, some animals would and do eat exceedingly large bulks of food, and yet never fatten. Again, while the individual animals of all breeds show different capacities for feeding, there are certain breeds the animals of which, as a rule, display opposite characteristics: this one is celebrated for its quickly fatting characteristics, as the shorthorn; another is no less well known as one which will not fatten quickly, as the Kerry breed. This arises chiefly from what may be called the temperament of the breed—the shorthorn possessing that placidity which promotes, the Kerry that restlessness of temper which hinders fatting. Again, the age of an animal influences its fatting capacities. Further, the kind of the animal modifies the style of feeding and the character of the food. Thus, an ox designed for the butcher is obviously required to be fed upon different food than a cow designed to give milk in return for the food which is given to it. A horse requires, from its constitution no less than the work it has to do, different food from that given to cattle. The age of the horse is also a point which influences or should influence the kind and quality of food given to it. Bulk is not required so much as nourishment: food rich in flesh-formers ought to be given, while that containing constituents for the formation of bone is also necessary. The formation of the frame and its filling up with sound firm flesh and muscle is what should be aimed at, not the formation of fat.

Peculiarities of Animals influencing their Fatting: Cleanliness.

And so on throughout the whole range of the practice of feeding of farm stock: it will be found that occasion is continually arising for the exercise of close observation, and a due and thoughtful consideration of all circumstances likely to influence the physical condition of the animals, as well as merely points connected with the foods themselves. This care of or attention to the animals involves considerations other than those already named, and which have special reference to the way in which they are individually kept, as regards their health and those circumstances which are likely to affect it. The cattle feeder, although not possessed of great intelligence or given to much observation, would know almost intuitively that it would be in vain to expect the animal to fatten if it was in a bad state of health. But to judge from a pretty wide series of examples one can meet with, it would appear to require a more than usually great degree of knowledge, and closer habits of observation than many feeders seem to be possessed of, to perceive that the way in which stock are kept may and does greatly influence their health. So that it is perfectly correct to say, that with certain methods of keeping animals it is just as vain to expect good results in fatting as it is known to be when they are obviously ill. What tends to make them ill should therefore be carefully avoided.

Take, for instance, the influence which the physical condition externally of the body of an animal exercises upon its health. That the functions performed by the skin are of great importance in the physical economy of all animals, man included, would seem to be a fact universally known. Yet how differently but too many feeders judge in the matter of their animals is evidenced by the absolutely filthy way in which they keep them. This arises from the almost habitual practice of many feeders in neglecting to draw analogies in their practice from the condition and physical circumstances of man. Good feeders, on the contrary, know that their animals require to be kept as clean in their bodies as their children and themselves are in person. It is quite impossible for an animal to thrive if functions of the skin are not allowed due development. This is best shown by the condition of its hide, or "coat" (to use the technical expression); this, indeed, as we have shown, affords one of the best tests to judge of the value of the animal as one of a certain breed, and if it be not present the animal will not be a thriving one. Cleanliness will not, of course, alone give the distinguishing marks which the coat of a pure-bred animal has, but it will improve the condition of the coat of a good animal; and in all cases, no matter what the breed, or want of it, the health of the animal will be greatly benefited. Where the hide or coat is left in a state of perpetual filth—for that is the word which designates its condition in too large a number of animals, with the ordure matted on in places—the functions of the skin will not be carried on as in a healthy animal they are carried on. To some it will seem an over-refinement in cattle feeding when we strongly recommend the coats of all fattening stock to be frequently and regularly brushed. We prefer to use a hard brush, not judging the usual horse currycomb to be well suited for the purpose, for the treatment while cleaning the coat should be gentle. If so, the animal will show signs of gratification with the process—which evidences of physical pleasure all true and good breeders will try to multiply. A well pleased animal, other things being equal, will be one more likely to thrive in a true paying sense than one which is worried and irritated by cruelty and neglect.

No feeder desirous of being considered a good and scientific one will for a moment tolerate the presence in his herd of an animal with its flanks, etc., covered with patches of hard matted dung. If by any chance dung gets upon the body of the animal it will at once be carefully and completely removed, and the hide and skin beneath it restored to the condition in which the healthy secretions can be carried on. But this remark points to another condition which greatly influences the question of all foods. We have said that a good feeder would remove all dung or dirt from the hide of his animals; but this involves the notion that the dung or dirt was there. Now, a good feeder, knowing all the points of his art, would be saved the necessity of removing dung from the coats of his animals, for the simple reason that there would be no dung to get attached to them—that is, in the majority of instances, for occasions might arise when its presence could not be avoided. We are now alluding to that style of fattening or feeding cattle known as the "stall-fed" or "housing" system. Cattle pasturing or grazing comes under another category.

Cleanliness in the Buildings Used by Cattle.

Good feeding on the stall-fed system requires therefore perfect cleanliness of the buildings in which the animals are kept. If the reader has had any experience of the style of farming carried out by the eminent breeders and feeders of cattle, or of celebrated dairymen, he must have observed with pleasure the perfect condition of cleanliness, not only of the animals themselves, but of their surroundings. We have been again and again in the stock-houses of eminent feeders, the condition of which as regards cleanliness almost justified the application of the saying "so clean you might have dined off the floor." The necessity of cleanliness in the interior of the houses in which animals are kept is well known to all who are acquainted with the laws of health, and the hygiene of our domestic animals depends upon the same laws, with but few modifications, as that of the human family. If the ordure of the animals be allowed to lie for any length of time even in but small patches or in out-of-the-way corners, the place generally having the appearance of being cleanly kept, the organic emanations proceeding from it greatly deteriorate the air. Our best authorities agree that these organic emanations are even worse than the foul air from breathing upon the health of the animals; although even the breath of animals is found contaminated with organic matter. When, however, the air of cattle-houses is contaminated, if the animals are subjected to this foul air habitually they display all the evidences of a low, unhealthy condition, under which no feeding, however good the materials may be, can be lucrative. On this subject of the air of cattle-houses, cognate to and influenced as it is by cleanliness, we need say no more here.

Quality of the Feeding Stuffs given to Cattle an Important Element in Cattle Feeding.

The feeding value of cattle-feeding stuffs is largely dependent upon their quality. If mixed with deleterious substances great losses may result, as they have often resulted in practice. But while the farmer in this matter is thus largely at the mercy or honesty of those who supply him with foods, he may himself be the cause of daily mixing his foods with deleterious or deteriorating substances. This he will be sure to do if he employs vessels and appliances such as feeding-troughs and boilers in a condition of what may be called chronic filthiness. This term describes with not a whit of exaggeration the state in which feeding troughs are kept by many feeders and dairymen. We have seen feeding-troughs which had apparently never been cleaned out from the time they were first used; and that from their appearance had been years before. Now, it is scarcely possible for such vessels to be used without their exercising a prejudicial influence on the health of the animals. The organic matter in some places, as in corners thickly crusted over, is sure to be in a state of decay more or less offensive, and always exercising a bad influence on the fresh food put into the vessels. And the sense of smell and taste is much more acute in animals than we give them credit for, and their dislike also to food which possesses a smell or taste not in the food in its normal or natural condition. They eat, doubtless, what is given them, as with them it is Hobson's choice —that or none; but a feeder thoroughly acquainted with the technicalities of his trade will take care that the animals under his care are not compelled by their hunger to partake of food of which, if they had a choice between it and a better, they would not partake. Little more needs be said on this subject: its mere statement should have been sufficient; for it must be obvious, on even exceedingly slight consideration, that dirt or decaying matter cannot possibly be beneficial to health when in direct connection with food. Yet more special attention to the point has been deemed necessary, for it is only those who have much to do with the general mass of technical workers who know how difficult it is to persuade them of the evil results of certain methods of working which they have long been in the habit of practising.

THE BUILDING AND THE MACHINE DRAUGHTSMAN.

CHAPTER XX.

Referring to the description of fig. 41—the projection of a pyramid—begun in the last paragraph of the preceding chapter, the plan of the pyramid at *l m n o p q* is a hexagon, and the hexagonal pyramid is shown in elevation at *r n' q'*, when the plan is looked at in the direction of the arrow 1. If the pyramid be cut by a line *v w*, parallel to its base *t u*, and the elevation be looked down upon in the direction of the arrow 2, the plan will be as at *x y*. As the cylinder and the cone are the bases of most important constructions in the preparation of working drawings, so is the pyramid—as also the prism—in the development of its surfaces. The application of this to working drawings will be hereafter shown; meanwhile we proceed to further illustrate the subject of projection of one or two of the objects shown in figs. 39, 40, explaining some points which will hereafter be useful when we take up working drawings in various departments of practical construction in connection with architecture and engineering.

The method of finding the lines of projection of a cone as cut by a line *m n* in fig. 40, oblique to its base *o p*, is illustrated in fig. 1, Plate CLII. Let B *c b* A be the frustoid of the cone, B *c* A the complete cone. Divide the line *b c* into any number of equal parts, as in the points 1, 2, 3, 4, and 5, and from point *c* draw any line *c f*. Then, from point *c* as a centre, with radii as *c* 5, *c* 4, etc., take over or transfer the points 5, 4, etc., to the line *c f*. At any convenient point, as *g*, draw *g h*, parallel to the axis of the cone, as *e h'*, and from points 10, 9, 8, etc., draw lines parallel to the base of cone *a d*, cutting the line *g h* in the points 11, 12, 13, etc. Continue the axis *e h'* of the cone *a e d* indefinitely, as to *i*, and at any convenient point in this continued line, as *q*, draw a line parallel to the base B A of cone. From point *q*, with distance *h'* A or *h* B, describe a circle *l r k m*, which will be the outline of the cone in "plan," when the elevation is looked down upon in the direction of the arrow 1, and which will be the view of the outside part of the cone, of which the elevation is at B *c* A.

To find the projection in plan of the sloping or angular face, *b c*, of the cone, as looked down upon in the direction of the same arrow 1, proceed as follows. From the points 1, 2, etc., on the side *b c* of frustoid of cone, draw parallel to the base *a d* the lines 1 16, 2 17, cutting the side *b* A of frustoid in the points 16 to 21 inclusive. Now, from the points on side *b c*, as 1, 2, etc., and those on the side *a b*, as 16, 17, etc., draw the ordinates or lines parallel to the axis *e h'*: the lines when extended will cut the line *l q k* in the points *n*, *o*, *p*, *j*, *r*, *s*, *t*, *u*, *v*, *w*, *x* and *y*. Then, from the point *q* as a centre, with *q y* as radius, describe an arc of a circle cutting the line *l q k* in the point *n*. The point *s* is that obtained by the ordinate drawn from *b* in the elevation; here the distance *s n* is that which is the major axis or transverse diameter of the ellipse, which forms the top of the frustoid on the line *b c*, seen as looked down upon in the direction of the arrow 1. To obtain the intermediate points of the ellipse in the plan proceed thus. From point *q* as a centre, with radius *q x*, describe an arc cutting the vertical ordinate drawn from the point 5 in the elevation in the point *a'*. With distance *q u*, from *q* as centre, describe the arc cutting the vertical ordinate drawn from 4 in the elevation in the point *b'* in plan. From same centre *q*, with radii taken successively as *q v*, *q w*, *q t*, describe arcs cutting the ordinates dropped from 3, 2, and 1, in the points *c'*, *d'*, and *e'*. These are all points in the curve of the ellipse required; and by drawing a curved line from point *n* to *s*, passing through the points *a' b' c' d'* and *e'*, half of the ellipse will be obtained. The other half will obviously be obtained in the easiest way by simply continuing the vertical ordinates indefinitely below the line *l q k*, and making the distance *o o'* equal to *o a'*, *p p'* equal to *p b'*, etc., and drawing through the points a curved line which will complete the ellipse, which will be plan of top of frustoid in elevation on the line *b c*, and this placed in precise relation to the circle *i l k m*, which represents the base of the elevation, and part within the lines A B, B *c*, *c d*, *d* A.

We have next to obtain the view of the top of frustoid in elevation on the line *b c*, as seen when looked upon in the direction of the arrow 2. This is also an ellipse, which will be more fully illustrated in a succeeding chapter, where we show the application of the conic sections to the preparation of working drawings. This view now required is projected on the line *g i''*, which is cut by the ordinates drawn from points 10, 11, 12, etc., on the line *c f*, which points we have shown how to obtain in a preceding paragraph. Take from the plan the distance *j c'*, and set it off from the point 13 to the point *q'* on the line 8 13, with the distance from plan *p b'* set off from points 12 and 14 to points *r'* and *t'*, and with distance *o a'* in plan set off from points 11 and 15 to *s'* and *u'*. Through the points *s'*, *r'*, *q'*, *t'*, and *u'* draw a curved line joining the points *i''* and *i'*. This will give half the curve of ellipse. The other half can be put in in the same way as that described in connection with the ellipse in the plan. Or while setting off from points 13, 12, 11, 14, and 15, on the right side of the centre line *i' i''*, by setting off the distances to the left, cutting the corresponding ordinates, as 8 13, in the point *v*, any necessity to take further measurements will be avoided. We have thus the completed projection of the frustoid of cone, shown in elevation at *a b c d*.

Projection of a Cylinder.

In fig. 2, Plate CLII., we illustrate in like manner the projection of a cylinder cut with a line oblique to the base. In this the elevation is in diagram A, the plan of base of cylinder in D, the plan of A looking down in the direction of the arrow 1 is in diagram C; the side elevation, looking in the direction of the arrow 2, is in diagram B. The reader should be able, from what we have already given, to find the projections as shown, but the following brief notes will indicate the mode of procedure. The plan, diagram D, of base of cylinder is divided into, say, sixteen equal parts on the same circumference 3 4 5, in the points 6, 7, 8, 9, 10, 11. These points are taken over to the dotted circle in diagram C by the dotted lines as shown, giving the points 11, 12, 13, 14, 15, and 16. From these points vertical ordinates are drawn, cutting the base line of A in elevation. Through point of axis of cylinder draw a line, and take over to this line the points as shown in diagram B. These points give the starting points of ordinates drawn as shown, which intersecting with those drawn from diagram D, will give the points of the ellipse of plan in diagram C.

In fig. 3, Plate CLII., we give the projection of a canted cylinder, with the upper part cut by a line oblique to its base. A is the elevation; D the plan, looking down on A in the direction of arrow 1; B the side elevation, looking at A in the direction of arrow 2; while C is the plan of B, looking at it in the direction of the arrow 3. The reader should be able to project the views here given.

Projection of Plans of a Building.

In preceding diagrams we have illustrated the relation which different views of the same object have to one another; and how the lines of one can be obtained from those of another. The reader should now be prepared to understand the following illustrations, in which this principle is elucidated in a set of practical drawings. Those, in fact, illustrate the projection of working drawings, the lines and points of one of the subjects giving data for finding those of another. The subject chosen is the design for a pair of detached, or as the arrangement is technically termed, "semi-detached" cottages. In commencing to lay down the "working drawings of a house," the "ground plan," as in fig. 2, Plate CLVIII., is usually, indeed we may say universally, drawn first. This not merely because the internal arrangement of the rooms is the most important matter for which the house is designed, but because it gives the points from which the leading lines of the front elevation, as in fig. 1, Plate CLVIII., are put in. These two drawings, the "ground plan" and the "front elevation," are so placed on the sheet that the lines of the one can be drawn to give those of the other. This is shown in figs. 1 and 2 of Plate CLVIII., fig. 2 being the ground plan and fig. 1 the front elevation. The pupil will see how by drawing first lines so as to be easily erased, as they are not permanently inked in—from the points *a*, *b*, *c*, and *d*, in fig. 1, Plate CLVIII., corresponding points are obtained in the line *a d*, fig. 2. The depth of the base or plinth is put in, and the line *e f*, fig. 1, drawn through the lower point, forming the "ground line" of the design. In drawing in the plan where one side is a "repeat" of the other, the quickest way is to start from a "centre line," as *e f* in fig. 1, Plate CLVIII., and set off the various distances right and left of this. The size of the sheet, as well as the taste or wish of the draughtsman, dictate the arrangement of the various views upon it. The "chamber (or second storey) plan" may be drawn at a convenient distance below the "ground plan," and the "back elevation" below the "chamber plan." By this arrangement it is obvious that much time will be saved in transferring distances, should the chamber plan and back elevation be drawn on another part of the sheet of paper. Thus, suppose this arrangement to be adopted, the lines *a*, *b*, *c*, and *d* of fig. 2, Plate CLVIII., are extended faintly downwards, so as to give the corresponding points *a*, *b*, *c*, and *d*, for the chamber plan in fig. 5, Plate CLVIII. The various partitions or divisions between the different apartments being drawn in fig. 2, Plate CLVIII., the lines of these can of course be taken down to the "chamber plan," as in fig. 5, Plate CLVIII.; *g*, *h* and *i* show corresponding points. The chamber plan being drawn completely, the lines of the back elevation, as in fig. 4, Plate CLVIII., can be obtained by taking down lines from the points *e*, *f*, in fig. 1, Plate CLVIII., to give corresponding points on the ground line *a b* of the back elevation.

But where the size of the sheet, or other circumstances, necessitate an arrangement of the different views upon it, more time is required to find the points of the lines of the chamber plan and back elevation; the whole having to be transferred from the ground plan. In drawing the chamber plan and back elevation under these circumstances, the first thing to be done is to draw a centre line, as A B, figs. 4 and 5, Plate CLVIII., corresponding to 4′ 4, *e f*, in fig. 1. The various distances in the direction of the length of the plan in fig 2, Plate CLVIII., are then taken in the compasses, measured from the centre line *e f*, as to *a*, *b*, *c* and *d*, and then transferred to fig. 5, Plate CLVIII., from the point *g*. The distances of the breadth or depth of the ground plan, fig. 2, Plate CLVIII., as from point *f* towards *e*, are then taken and transferred to fig. 5, from the point *g*. The chamber plan being completed, the lines are taken from it to give the points of those of back elevation, as by extending *e f*, fig. 5, to *a b*, fig. 4, Plate CLVIII.

The vertical heights of windows, roof, etc., of the front elevation are obtained with the greatest accuracy from the "tranverse" section, which is shown in fig. 5, Plate CLXXV. The vertical lines of this correspond to the lines drawn from the points *h, i, j, k, l, m*, and *e*, fig. 2, Plate CLVIII. These distances may be transferred from fig. 2 to the ground line *a b*, fig. 5, Plate CLXXV., starting from the point *c*. The cross section being completed, the vertical heights, as *c d, c e, c f*, etc., are transferred to the front elevation in fig. 1, Plate CLVIII., from the point on central line where it cuts line *e f* upwards. The dotted lines, as 13, 14, etc., fig. 5, Plate CLXXV., being carried across, show how these may be transferred at once to the front elevation in fig. 1, Plate CLVIII., and the back elevation in fig. 4, same Plate. These lines will give also, of course, the heights for the end elevation in fig. 2, Plate CLXXV., when transferred to line *c d*. So also for the other end elevation, in fig. 3, Plate CLXXV. In some designs, both end elevations being exactly similar, only one end elevation is required. When they differ in plan, two are required, or may be considered necessary. In fig. 2, Plate CLVIII., the lines 8, 9, 10, 11, and 12, being extended, will give the points of the depth of the chamber plan in fig. 5, Plate CLVIII.; so also of the end elevation in fig. 3, Plate CLXXV., although this will be in a reversed position. We have so put it that it may illustrate the points we have in view. The lines of the end elevation in fig. 2, Plate CLXXV., across its breadth are obtained by taking the distances, as *b a, a n, a o, a p*, and *a q*, and transferring them to line *a b*, fig. 2, Plate CLXXV. Fig. 3, Plate CLVIII., is the "cellar plan." The pupil should carefully study the whole of the drawings from fig. 1 to fig. 5, Plate CLVIII., and figs. 1, 2, and 3, Plate CLXXV., in relationship to one another, taking care to draw them for himself. This will give him in a day more practical thought as to the projection of the different views of any given subject, than a month devoted to reading descriptions of drawings and examining these.

Perspective Drawing of Building Plans.

We have in a preceding chapter in the present series explained how, while in the drawings—more or less specifically known as working drawings—connected with the constructive arts of architecture and engineering, the ordinary projection or plane projection is used, that for certain purposes of the architect perspective drawings are required, such as houses and other structures, but that for the work of the engineer, especially in the department known as mechanical, ordinary perspective drawings are rarely required now. Formerly they were, in certain special cases, where what may be called a picture view of a structure, such as a bridge, or of a machine, was required for business purposes. Now the aid of photography is almost universally called in. And this is very easily adapted, as the structures or machines are already finished or constructed. But in the case of purely architectural subjects, such as a domestic building, a perspective or picture view may be—and often is—required, to show the party who may be proposing to build a house for himself, and who has a desire to see "how it would look when built." The house not being actually constructed, photography cannot be availed of, as in the case of a machine, photographs of which are generally taken merely for trade or catalogue or prospectus purposes. The architect, therefore, who is asked by his client to let him have a "picture" or perspective view of the proposed house—for he cannot, as he meekly confesses, "understand those plans and sections all on the flat"—is compelled either to prepare, from his knowledge of the peculiarities of the "style" and construction and arrangement, an ideal sketch as it appears in his own mind, or to prepare a "regular perspective drawing." If a clever artist as well as an architect, he will readily enough "throw together" a sketch which will give a very good idea of how the house will look when built, and which, although it may be of a comparatively simple character, will satisfy the requirements of his client. On the other hand, if a regular or "finished" perspective view of the house is to be made, the drawing is "projected" according to the principles of ordinary perspective—or, as it is almost universally designated, "perspective" simply. What we have here to concern ourselves with is only the application of those principles to the preparation of a perspective drawing of a house, for example, of which the plans are drawn on the ordinary system of plane projection (see the preceding chapters in the present series, also the "Young Architect"). These plans are in all cases required by the architectural draughtsman, as they afford the data from which the lines of the perspective drawing or elevation are produced. How the lines are obtained we now proceed to show.

How to Project Building Plans in Perspective.

In the article headed "The Young Architect" it is stated that a perspective sketch showing the *exterior* of a proposed new building is generally prepared by the architect for his client, to show its actual appearance, which cannot be conveyed by geometrically drawn elevations. It is very desirable that the architect should be able to prepare these drawings himself and when the theory is thoroughly understood there is no difficulty in applying it to every case, however complicated, that may arise.

THE COLOUR MANUFACTURER.

WITH PRACTICAL NOTES ON THE USE OF PAINTS AND DYES IN DECORATIVE WORK.

PART FIRST.—PIGMENTS.

CHAPTER IX.

AT the conclusion of the preceding chapter (p. 321, vol. ii.), in describing the method of producing chrome greens, we showed how a "fast" shade of this colour could be obtained. Ferric hydrate treated similarly yields of course a deep rust-red of ferric oxide, Fe_2O_3. Such is the principle of the manufacture of chrome greens, except that the chromium oxide is generally obtained by other more economical methods from cheap compounds of chromium, and that a portion of the water of hydration generally remains in the finished product. The reactions which take place in the above are thus represented:—

$$(1)\ Cr_2Cl_6 + 6NH_4OH = Cr_2(OH)_6 + 6NH_4Cl.$$

$$\begin{array}{ccccccc}\text{Chromium chloride} & + & \text{Ammonia} & = & \text{Chromium hydrate} & + & \text{Ammonium chloride.}\end{array}$$

$$(2)\ 2Cr_2(OH)_6 + \text{heat} = 2\,Cr_2O_3 + 6H_2O.$$

$$\begin{array}{ccccc}\text{Chromium hydrate} & = & \text{Chromic oxide} & + & \text{Water.}\end{array}$$

Other methods of obtaining chromium oxide depend upon the decomposition of bichromate of potash or soda: for example, when simply ignited oxygen is given off, carbonate of potash or soda is formed, and insoluble chromium oxide remains. On treating this with water the alkali is dissolved out, and the product consists of Cr_2O_3.

Making Chromium Oxide Greens.

The following are the best and most important methods of making oxide of chromium pigments. In the first place, chromate of potash or soda is manufactured from chrome-iron ore, which is a plentiful mineral consisting mainly of protoxide of iron and oxide of chromium, $FeOCr_2O_3$ or Cr_2FeO_4, but frequently containing also alumina, magnesia, and protoxide of chromium, and containing from 30 to 50 per cent. of chromic oxide. The one, in a state of fine powder, is treated in crucibles with soda ash, $NaCO_3$, and saltpetre, NO_3, on the hearth of a reverberatory furnace. The oxygen of the alkali-nitrate oxidises the protoxide of iron and the sesquioxide of chromium, the latter into chromic acid. The sintered mass, after ignition, is ground up and treated with boiling water, and the chromate of potash formed is obtained in solution. Wood vinegar is added to the chromic solution, whereby the alumina and silica are precipitated, and the clear liquid is evaporated, and crystals of the neutral chromate of potash are obtained. To convert these into the acid chromate or bichromate, the equivalent quantity of a strong acid, such as sulphuric or nitric, is added, which unites with a portion of the potash, and on allowing the liquid to crystallise, bichromate of potash is obtained. Other methods of treating chrome iron ore, previous to conversion into oxide of chrome, are industrially applicable, but this illustrates the points involved sufficiently well for our purpose. Another method consists in heating the pulverised iron-chrome ore with chalk, grinding and then adding water, and then enough sulphuric acid to the mixture to decompose the excess of chalk and a portion of the lime of the chromate of lime, and so form the bichromate. To the bichromate of lime, thus formed, carbonate of potash is added; carbonate of lime is thus thrown down, and bichromate of potash remains in solution.

From the neutral chromate of potash or soda oxide of chromium is obtained by calcining three parts thereof with two parts of sal-ammoniac. The reaction is that ammonia is driven off, and oxide of chromium and chloride of potash or soda formed:

$$2Na_2CrO_4 + 4\,NH_4Cl = 4\,NH_3 + 5\,H_2O + Cr_2O_3 + 4NaCl$$

$$\begin{array}{ccccccccccc}\text{Neutral chromate of soda} & + & \text{Ammonium chloride} & = & \text{Ammonia} & + & \text{Water} & + & \text{Chromic oxide} & + & \text{Sodium chloride.}\end{array}$$

The ammonia is of course recovered in a condenser, and the residue is ground, extracted with boiling water, the chloride is dissolved out, and the oxide of chromium obtained as an insoluble fine green powder. Another method is to mix some gunpowder with the chromate of potash, well dried, and sal-ammoniac; this mixture is pressed into moulds and ignited. When finely powdered chromate of potash is mixed with about an equal weight of starch powder—farina or rice—and ignited at a high temperature, the result is the formation of oxide of chromium and carbonate of potash:

$$2K_2Cr_2O_7 + C_2 = 2\,Cr_2O_3 + 2K_2CO_3 + CO_2.$$

$$\begin{array}{ccccccccc}\text{Bichromate of potash} & + & \text{Carbon (Starch)} & = & \text{Chromic oxide} & + & \text{Potassium carbonate} & + & \text{Carbon dioxide.}\end{array}$$

The residue is treated with water, to extract the alkaline carbonate. When bichromate of potash is simply heated in the air, potassium carbonate and chromic oxide are formed; the former is of course extracted with water:

$$K_2Cr_2O_7 + CO_2 = K_2CO_3 + Cr_2O_3.$$

$$\begin{array}{ccccccc}\text{Bichrome} & + & \text{Air, containing } CO_2 & = & \text{Potassium carbonate} & + & \text{Chromic oxide.}\end{array}$$

When bichromate of potash is treated with concentrated hydrochloric acid, it is decomposed into oxide of chromium and chloride of potash, provided only sufficient acid be added to unite with the potash:

$$2K_2CrO_7 + 2HCl = Cr_2O_3 + 2KCl + 2H_2O.$$

Oxide of chromium may be obtained also by igniting an alkaline chromate with sulphur and extracting with water. When bichromate of potash is heated with strong vitriol, oxygen is given off, and an insoluble basic sulphate of chromium is formed, which, when treated with strong solution of caustic soda, yields a precipitate which, on filtering, drying, and igniting, to drive off the water, consists of chromium oxide.

Veridian or Emerald Greens.

These chromic-oxide pigments contain boracic or phosphoric acid; they are very brilliant greens, and extensively used. To prepare veridians the following methods have been found to yield excellent products. Phosphoric veridian is made thus: 39 parts of neutral phosphate of ammonia and 46 parts of bichrome are each powdered finely, mixed, and then made into a thick paste with water. This is then carefully dried, and afterwards ground up and heated to 195° C. for half an hour. The residual mixture of chromic oxide and phosphate of soda is then washed with water to remove the latter—which is, however, not done perfectly. Boric veridian is made by igniting at a dull red heat 3 parts boracic acid with 1 part bichrome, washing to remove the soluble boracic acid.

Properties of the Chromic Greens.

Well prepared oxide of chromium, combined with more or less of water, yields pigment greens possessing all those qualities required in ordinary industrial decoration or painting. Chromic oxide is a stable compound, not affected by the prolonged action of the air and light; neither do sulphurous fumes discolour or otherwise injure it. It may be safely used in combination with any of the usual pigments, whether in painting, in paper staining, or in tissue printing. In painting, oxide of chromium greens work well either in water or oil. In tissue printing the albumen with which they are usually fixed is not coagulated thereby, and consequently the colour works well, which in paper-staining glue and other sizing and fixing materials do not injure the greens. They are much to be preferred to arsenic greens, on account of the poisonous nature of the latter. The shades yielded by chromic-oxide greens vary in depth chiefly according to the state of hydration of the oxide—ranging from pale, dull green, through rich, deep greens, to very dark shades. The quality known as "veridian green" is a carefully prepared pigment well suited in painting for "marine effects."

Testing Chromic-Oxide Greens.

As in the case of most other pigments, the safest method of ascertaining the practical value of a sample of chromic-oxide green is to make comparative trials on the small scale to ascertain its shade, covering power, transparency, and other qualities, of which the practical colourist is the best judge. Nevertheless, valuable information can be obtained by a chemical examination, as these pigments are no less subject to impurities or adulterations than most other pigments—many samples of chromic greens being mixtures.

Prussian blue may readily be detected by the loss of colour on treating the sample with a solution of caustic soda; by then igniting, dissolving in hydrochloric acid, filtering, and adding ferrocyanide of potash, a copious blue precipitate, derived from the iron of the Prussian blue, is obtained.

Ultramarine blue is detected by adding dilute sulphuric acid, when the odour of sulphuretted hydrogen (that of rotten eggs) indicates its presence.

Chrome yellows may be detected by the methods described when treating of yellows.

Chromic oxide when heated with concentrated hydrochloric acid dissolves, and the solution gives a green precipitate with ammonia or caustic soda, which dissolves in excess of the latter; and partially dissolves in excess of ammonia, but is re-precipitated completely on boiling.

Having now glanced at the green pigments derived from chromic oxide, we arrive at those greens derived from compounds containing copper; and begin, as in the case of chromium, by describing briefly some of the chief properties of compounds of copper, upon which depend their application as pigments.

The Chemistry of Copper Compounds.

Many of the compounds of copper are either blue or green. Of these a considerable number, as we shall presently see, are insoluble in water, and are of such stability as to be applicable as pigments. With oxygen, copper unites in four proportions, forming the tetrant-oxide, Cu_4O; the hemi-oxide or cuprous oxide, Cu_2O; the monoxide or cupric oxide, CuO; and the dioxide or cupric peroxide, CuO_2. The first of these, the tetrant-oxide, is of an olive-green colour when excluded from oxygen, but on exposure to the air it rapidly becomes further oxidised, and changes to the tint of cuprous oxide, Cu_2O. This latter compound is of red colour, and occurs in nature in a crystalline state, as cuprite, or red copper ore. It may be prepared from sulphate of copper by adding an excess of caustic soda and then sugar, and boiling, when the cuprous oxide is at once precipitated as a red crystalline powder. The *hydrated* cuprous oxide, $(Cu_2O)_4 \cdot H_2O$, is a yellow-coloured compound obtained by adding caustic soda or ammonia, not in excess, to a solution of cuprous chloride. The precipitate dissolves in ammonia to a colourless liquid, which, like the precipitate itself, rapidly oxidises to a blue colour on exposure to the air. The third oxide of copper, the monoxide, CuO, is black, and occurs in nature as *melaconite*; and it is formed when a salt of copper such as the carbonate is ignited. The *hydrated* monoxide, $Cu(OH)_2$, is of a bright-blue colour, produced by mixing a little soda with solution of sulphate of copper. The dioxide, CuO_2, is of light-brown colour, very unstable, readily splitting up into the monoxide and oxygen, obtained by oxidising $Cu(OH)_2$ by means of hydrogen dioxide.

THE CALICO PRINTER.

THE CHEMISTRY AND TECHNICAL OPERATIONS OF HIS TRADE.

CHAPTER XVI.

Colouring-Matters: Blue and Violet Pigments (*continued*).

AT end of preceding chapter we began our notice of ultramarine blue, the chief pigment blue colour. Little was known of its composition until, in the year 1814, M. Jassant found a blue substance in a soda furnace and submitted it for analysis to Vauquelin, who found it possessed the same composition as the rare and costly *lapis* stone. Shortly afterwards Messrs. Guimet and Gmelin discovered the method of manufacturing this substance commercially.

Ultramarine Blue is a compound of complex composition, consisting chiefly of silica, alumina, sodium and sulphur. It varies in composition according to the conditions of manufacture, but the pure compound is of a magnificent deep-blue colour; the colour of commercial ultramarine varies within wide limits according to manufacture. Light blue, dark blue, green, violet, and red ultramarines are now in the market. Ultramarine blue possesses the peculiar property of assuming a paler shade on being subjected to a *grinding* process; and hence pale shades of pure ultramarine are more expensive than the dark shades; generally, however, the former are obtained from the latter by admixture with white pigments such as sulphate of baryta.

When an acid, as hydrochloric or sulphuric acid, is added to ultramarine, it is decomposed; sulphur combined with hydrogen, or sulphuretted hydrogen, H_2S, is given off, and silica separates.

Ultramarine is printed and fixed in the same way as most pigments—by albumen and steaming. The colour is fast against alkalies and sunlight; but dilute acids and acid salts destroy the colour with liberation of sulphuretted hydrogen—recognised by its characteristic odour. This reaction serves to distinguish ultramarine from other blues.

Prussian Blue.—This is applied both in the form of a pigment, printed-on with albumen and steamed; and also by printing-on a mixture of potassium ferrocyanide and an acid such as oxalic, sulphuric or tartaric, and steaming. Prussian blue is a compound of ferrocyanic acid, HCNFe, and iron oxide, Fe_2O_3, and is formed when ferric sulphate and ferrocyanide of potash are mixed together. It is fast against acids and light, but is destroyed by soap and alkalies, with formation of oxide of iron. For the latter reason its use is comparatively restricted. When ferrocyanide of potash and oxalic acid are printed-on and steamed, Prussian blue forms in the fibres of the cloth.

Several other mineral blue colouring-matters are known—such as Prussian blue, cobalt blue—but are now not in use.

Yellows.

The chief are sulphides of cadmium and of antimony, bisulphide of tin, oxide of iron, yellow oxide of lead, and chromates of lead, zinc, strontia, and lime. Lead yellow, or chromate of lead, is the most important.

Lead Yellows are used both in the form of pigments, printed with albumen and steamed; and by printing on as salts of lead and passing the cloth through bichromate of potash. Yellow chromate of lead, $PbCrO_4$, is formed when chromate of potash or soda is added to a soluble salt of lead, as the acetate or nitrate. Orange chromate of lead, $Pb_2Cr_2O_7$, is formed by adding bichromate of potash or soda to a soluble lead salt. The yellow variety is used generally as a pigment; the orange variety both as a pigment and by printing-on acetate of lead, steaming, and passing through bichrome. Chromates of lead are insoluble in water, and are fast colours against soap and light; hydrochloric acid and sulphuric acid, however, destroy them, with formation of the white chloride and sulphate of lead respectively. Strong alkalies also destroy chromates of lead.

Iron Yellow or Buff is used both as a pigment and by printing-on sulphate of iron and passing through caustic potash. Iron buff is the ferric oxide, Fe_2O_3; and is formed by the action of caustic soda upon ferric salts; or by adding caustic soda to ferrous sulphate (copperas), and allowing to oxidise in the air. It forms a very fast colour, unaffected by light, soap, or strong alkalies. It is largely used in calico printing.

Greens.

The following mineral greens are used:—Chrome greens, arsenic greens, mixtures of yellow and blue pigments. The most important of these are chrome greens.

Chrome Greens are applied in the form of pigments. They are generally oxides of chromium, produced in several ways. (1) By igniting many compounds of chromium, such as sulphate of chrome and chromate of potash. (2) Guignet's green is generally obtained as follows:—Three parts of boracic acid and one of bichromate of potash are mixed up together with a little water and heated to a dull-red heat in a furnace. The mass resulting, consisting of borates of potash and chromium, is allowed to cool, and thrown into water, when the former salt dissolves and the latter decomposes, forming a brilliant green precipitate ($Cr_2O_3 + 3H_2O$), which is collected and washed, and forms much of the chrome-green paste of commerce. It forms a fine pigment of bright green colour, fast to soap, strong alkalies and sunlight. It is extensively employed.

Scheele's Green is applied generally as a pigment. It is an arsenite of copper, $As_2O_4Cu^{11}$ (?), and formed when a solution of arsenite of soda is added to sulphate of copper (blue-stone). It gives a beautiful fast green, but its poisonous nature prevents its extensive use.

Emerald Green is the double acetate and arsenite of copper, $Cu_2\left\{\begin{matrix}AsO_3)_2\\ CrH_3O_2\end{matrix}\right.$, formed when concentrated solution of acetate of copper and arsenite of soda are heated together. It is also formed by boiling Scheele's green with acetic acid. Its formation may be represented as follows:—

$$4CuAsO_4+2C_2H_4O_2=2Cu_2\left\{\begin{matrix}(AsO_2)_3\\ C_2H_3O_2\end{matrix}\right.+H_2O+As_2O_3.$$

Browns.

Browns are obtained from oxides of iron and lead, with addition of varying amounts of red and yellow pigments; also from manganic oxide.

Manganese Brown or Bronze.—This is the oxide of manganese, Mu_2O_3, formed when caustic soda is added to a solution of a manganese salt, such as sulphate, and boiled or exposed to the air to oxidise. It is a fast colour.

This section may be again returned to, and in fuller terms.

(2) VEGETABLE COLOURING-MATTERS.

Madder.

Although this product has been entirely superseded by artificial alizarine, we will give a short account of this once-important dye-ware. Madder is the root of the *Rubia tinctorum*, a plant native of Central Asia, but once extensively cultivated in various parts of Europe and America, New Zealand, and other parts of the world. The colouring principle of madder is termed alizarine or alizaric acid ($C_{10}H_6O_3$), which yields, with alumina, a splendid scarlet, and various shades with other metallic oxides; it also contains an allied substance, purpurin, besides various brown and yellow colouring-matters.

Garancin is obtained from madder by treating three parts by weight of ground madder with one part of cold concentrated vitriol, adding water and boiling; the residue is then washed, dried, and ground, with addition of some chalk to neutralise any free acid remaining. Garancin is still produced in small quantity by a process similar in principle to the above, the operation being conducted with great care, and high-pressure steam being made use of in the treatment. It is employed chiefly for dyeing what are termed "garancin styles," chiefly for dark browns, lilacs, and chocolates.

Indigo.

Indigo is a natural colouring-matter, and one of the most important amongst both ancient and modern dye-stuffs. It yields one of the fastest of blue dyes. The chemistry of indigo is complicated and interesting.

Occurrence of Indigo.—Indigo is obtained by subjecting certain plants to a process of moist fermentation, whereby an insoluble, deep-blue-coloured compound is formed, and known as *indigotin*, which, collected from the fermenting vats, is formed into a more or less impure product known as *indigo*. The plants mainly used for the production of indigo are species belonging to the genus *Indigofera*, cultivated in many parts of India, especially Bengal and Java. Indigo arrives in this country in the form of solid lumps or pieces mostly of a deep blue or violet colour, but varying greatly in appearance as well as in purity.

Composition of Indigo.—The colouring-principle of indigo is termed *indigotin*. The amount of indigotin present in different commercial brands or qualities of indigo varies from 7 to over 90 per cent.—the greatest bulk of the indigo in the market containing from 30 to 50 per cent. The other constituents of indigo are (1) brown and red coloured organic substances; (2) mineral or earthy matters, chiefly lime, magnesia, silica, and iron; and (3) water. The brown and red colouring-matters present in commercial indigo modify to a greater or less extent the shade of blue obtained therefrom, but not so materially as to render the amount present of any great moment in choosing a quality of indigo to buy. We now give three analyses of indigo—representing poor, medium, and rich qualities respectively.

(1) Cheap "figged" indigo, of blue-slate colour and exhibiting a dull appearance and heavy—in irregular-shaped lumps, contained indigotin, 8·5; organic matter (namely, red and brown colouring-matters, woody fibres etc.), 21·2; ash (consisting of salts of lime, magnesia, alumina and iron, and a large amount of sand), 64·5; and water, 5·1 in 100 parts. (2) A sample of indigo, considered of moderately good quality, in pieces, mostly square, and about 2 cubic inches, deep-blue colour, and exhibiting a coppery lustre when rubbed with a hard substance, contained indigotin, 37·8; other organic matters, 51·0; ash, 7·7; and water, 5·0. (3) A rich quality of indigo, largely used for indigo printing, of an intense violet-blue colour, exhibiting when rubbed a coppery metallic reflexion, and of light weight, contained 70·9 of indigotin, 17 of organic matters, 4·1 of ash, and 7 of water. Richer qualities of indigo than this last are of rare occurrence in the market; this quality, however, is in large and increasing demand, especially for direct indigo printing, for which purpose indigo of the purest possible kind is desired.

Properties of Indigotin or Pure Indigo.

(*a*) Appearances and action of heat.

Indigotin, the colouring-principle of indigo, and obtained from the latter by careful sublimation, is a deep-blue substance of peculiar odour.

THE STEEL MAKER.

THE DETAILS OF HIS WORK—THE PRINCIPLES OF ITS PROCESSES—THE QUALITIES AND CHARACTERISTICS OF ITS PRODUCTS.

CHAPTER X.

IT is a curious commentary on the whole aspect of the phase named at the end of preceding chapter in the history of the Bessemer process that neither those who so bitterly opposed it, nor, so far as we know, the inventor, had at this time even the remotest conception of the magnitude of the trade affected by the success of this experiment—pre-doomed, so to say, by its promoters to show the discovery to be a failure,—a trade so great that while it placed within the reach of the founder a "potentiality of becoming rich beyond the dreams of avarice" which in his case has been truly realised, places also within the reach of the very trade who denounced and hindered it a possibility of becoming rich far beyond even sanguine anticipations—a possibility also converted into fact. If the fortunes made out of the Bessemer process of steel making, not only the gigantic one made by the fortunate and justly fortunate inventor himself, but by the numerous ironmasters and firms throughout the world—for so widely has the discovery been practically applied—were summed up, it would show an aggregate of wealth which might well be considered fabulous.

But while this great discovery met, as we have thus seen it to have met, the indifference of the general public, the direct and persistent obloquy with which certain men of science—for the time at least not deserving of the designation, forgetful as they were of what constitutes true science—treated it, the imputation of motives shamefully detractive of the integrity and uprightness of the inventor, and, above all—for this directly struck at his hopes of that pecuniary success which every inventor is entitled to look forward to as *one*, but not the only, reward of his labour—the determined and truly bitter opposition offered and for so long maintained by "the trade," the reader will doubtless conclude that at least the Government held out the hand of encouragement to Mr. (now Sir Henry) Bessemer, and gave him an early opportunity to prove the value of his process in making that metal of which such enormous weights are required for the purpose of national defence. But this also was not to be. To those who, like the writer of these lines, are somewhat intimate with the details of the history of the Bessemer process of iron and steel making, it is painful to call to recollection all that the inventor had to suffer at the hands of the Government. Little service would here be done by recapitulating the details of this treatment, but much may be done as drawing attention to what in reality constitutes a blot on our national and social *morale*, by recording the simple fact that this treatment was characterised by anything but fairness and sterling uprightness. This will best be illustrated by one fact. While the inventor was "officially" informed that "the department" (at our great national arsenal at Woolwich) could not adopt his process, inasmuch as the metal it produced was quite unfitted for the making of the ordnance—for which it was specially required—the department, in despite of this, did nevertheless adopt and carry on the process, and with such decided practical effect that for years they made, and are now still making in this way, enormous weights of steel in the manufacture of that very ordnance for which, in their official statement to Sir Henry Bessemer years ago, they declared the process to be "totally unfitted." We can give no higher praise to the nevertheless fortunate inventor than by stating that we have heard Sir Henry detail personally his dealings with the Government without the expression of a single sentiment, or indeed the display of any feeling, but that which was dictated by charitable and gentlemanly—gentlemanly because truly charitable—principles. It is not every mind which can rise supreme to feelings naturally created by a strong sense of unfair and inconsiderately unfeeling treatment. It is not that such minds are not sensitive—on the contrary, they are keenly and unusually so; it is only that they are well-balanced minds which will not be swayed by or be allowed to swerve from right-minded conduct. We have for a direct and special purpose been thus particular in glancing—for after all it is but a glance our space has permitted of—at what are some of the features of the early history of this the greatest discovery of modern times in the industrial arts,—as some, at least, of our young readers may derive lessons which may be of service to them in their future life.

We now take up what is the history of the scientific and practical details of the Bessemer process, which, as we have stated, has revolutionised the practice of modern steel making, so far as what are now almost universally called "mild steels" or "ingot steels" are concerned as distinguished from the hard steels, which, being capable of being hardened and tempered, are used in the making of all kinds of tools and cutting instruments. But those mild or ingot steels, although limited in one sense in their application to certain industrial purposes, may be said to be practically unlimited in their application to another and an exceedingly wide range of constructive purposes. In a word, for all the uses to which cast iron and wrought iron—more especially the latter, which in turn was a substitute for cast iron—have been put, these mild steels offer all advantages which those two long-established metals give.

The Bessemer Process of making Steel (*continued*).

To understand the special points connected with the early practice of the Bessemer process, it will be necessary for the reader to turn to the series of chapters entitled "The Iron Maker," in which the process of making wrought iron is detailed, and of which the making of steel on the old-established system as described in the last chapter of the present series is but an outcome or after result. We might have treated the two subjects of iron and steel making under one head, but we have adopted the dual treatment to secure easy reference and other advantages more or less obvious.

In the above-noted paper on iron making, in the chapter detailing the process for producing wrought iron, we have said that the generally accepted theory to account for the results of the refining or refinery process was a very simply stated one, it being held to be a mere oxidising process; the oxygen of the air blast, combining with the carbon of the iron, forming carbonic oxide and carbonic acid gas, and with the silica forming silicic acid. But it does not extend so far as to get rid of the sulphur and the phosphorus: this elimination the puddling process effects, though in a way which has not been so precisely traced as that the theory of its action is accepted without question.

Perhaps the one most generally accepted is that the oxidising action of the air is not confined, as in the refining, to the surface only of the mass or masses of fused ore; but that in consequence of the manipulation to which the material is subjected in the puddling process, an internal oxidising action goes on, the oxygen so combining with the sulphur when thus brought "in such direct contact with all the material that it actually bubbles through it," hence the jets of carbonic oxide seem to rise as if from the very bottom of the whole mass in the puddling furnace. Sir Henry Bessemer apparently accepted this theory, and by carefully thinking the matter out, he succeeded so well that he was able at a very early stage of his labours to blow air through the mass of melted iron.

In the absence of a minutely detailed history of his invention, recording all the steps of his process of thought and of action in designing appliances, which the world would be but too glad to obtain from Sir Henry, and which would be something more than merely interesting, it is only open for us to conjecture —and the surmise is at least not unreasonable—that to some extent a great surprise awaited him when first he succeeded in so blowing air completely through the mass of molten metal he operated upon. For although Sir Henry blew air through the whole mass, which might reasonably have been supposed to present such physical obstacles as to make this an impossibility, in doing this he did much more. For the blast of air not only increased the intensity of combustion to a degree that must have been truly marvellous to him, but carried the fusion to a point, and brought about results which were still more astounding—the production of what in point of fact might well be termed a new metal. Those who for the first time have witnessed the operation of steel making by the Bessemer process, and been delighted and astonished to a degree far beyond their anticipation by that brilliant display before which the finest fireworks "pale their ineffectual fires," may form some conception of the feelings with which Sir Henry Bessemer witnessed the results of his first trials. With the daring of scientific genius he had foreseen that changes in the metal would be the result of his process; but it may reasonably be doubted whether he had foreseen that a process of combustion of so novel a character and productive of results so startling yet so beautiful in their changing characteristics lay before him. A result so singular that we need feel no surprise to know that when, in the year 1856, he announced to the British Association, then holding its annual sitting at Cheltenham, that he had discovered a method of making iron without fuel, the announcement created the greatest surprise in the scientific world. It did more. So thoroughly opposed were Sir Henry Bessemer's views to those at the time generally received by the metallurgical world—so directly counter his process to any known in the trade—that the flood of prejudice which took its rise in this ever-to-be-remembered "announcement" found vent in doubts and sneers, in statements and counter-statements, made not always with that courtesy and consideration for the feelings of others which is supposed to distinguish scientific men, till the whole of the "iron world" was in a ferment of excitement.

We need not detail the steps in the history of the early trials of the Bessemer process which led its inventor, by giving up all idea of overcoming the difficulties which those trials brought out, in operating with a fixed vessel, to adopt the principle of making the vessel itself movable, so that it could be charged with and emptied of its contents by simply changing its position. The reader is doubtless acquainted with that form of steam engine known as the "oscillating": in this the cylinder is centred upon two trunnions terminating the steam supply and exhaust pipes, placed at opposite ends of a diameter, the cylinder oscillating on these as centres, the ends describing short arcs of circles. This arrangement so completely includes all the elements of the "Bessemer converter" as it now exists, that it is far from improbable that Sir Henry took the hint for his converter from it. Nor, if he did, does it at all detract from the praise due to him for the ability of his conception. For it is one of the attributes of genius to transform the common things of the general into the treasures of the special,—possibly its highest effort to compel, so to say, things to assimilate which appear to the common eye to be hopelessly dissimilar.

The "Plant" or Mechanical Aids in the Bessemer Steel Making Process.

Marvellous as has been the development of the iron manufacture in this country, curious as have been the incidents connected with it—to such a degree, indeed, as to approach, if in many respects they do not surpass, the fanciful creations of fiction—there has been no period in the whole history so remarkable, round which so much has gathered, that has been in all its phases so curious and suggestive, and in a practical sense so interesting, as that connected with the invention, introduction, failures, struggles, and ultimate marvellous success of the Bessemer steel process: one which, as an authority remarks, is an interesting example of an invention or discovery securing ultimate and striking success, not in spite of, but through or in virtue of failures. At more points than one in the progress of the invention it seemed that a difficulty was such that there seemed every likelihood of the process being relegated to that limbo of unsuccessful inventions and discoveries the members of which are so unfortunately numerous. The difficulties did not lie so much in the direction of the mechanical appliances necessary for the working out of the invention and discovery—for it was both of these—as in points connected with what may be more strictly called the chemical features of the process. How these were overcome as they arose in some instances by those happy or fortuitous circumstances or chances by which many inventions are characterised, forms a singularly interesting chapter in the history of practical metallurgy. So far as the mechanical appliances necessary to work the process practically, the eminent talents of the inventor as a mechanician were quite competent to master them. And, as we have already pointed out, it is a striking exemplification of the skill of Sir Henry Bessemer in mechanical devices, that he struck out from the first a system of working which, in its main features, is the system of the present day. But as the process has developed from the experimental stages from which all discoveries or inventions start into a manufacture every day becoming more and more gigantic in its proportions, new arrangements have been introduced from time to time to facilitate the working or mere manipulation of the huge masses of metal with which it deals. The plant thus produced, under circumstances so novel, indeed, so utterly unlike those of the old and established methods of manufacturing iron and steel, has now reached a point beyond which it seems difficult to believe that there will be any further progress made, at least in the way of decided changes in the system. Improvements in the details will, no doubt, still continue to be made, as they are in fact being—have, at least up to within a very recent period, been—made from time to time; but it is reasonable to suppose that the main features of the system will remain as now. Compared with the bulky, numerous and costly appliances and plant of the old method, those of the new method are amazingly simple. The chief, or as it may be termed *the* feature, of the plant for making wrought iron and steel in the Bessemer process, is what Sir Henry called the "converter" or "convertor." The diagram in fig. 1 gives the reader a general notion of the form of this, and the method of using it. The pig or crude cast iron is not itself fused or melted in the converter, but this is used solely for the purpose which its name implies. The pig iron to be *converted* into steel is introduced to the interior of the convertor, *a a a a*, fig. 1. This, made of cast iron, has a fireclay or ganister lining, *b b*, calculated to resist for a time the action of the intense heat required, and largely generated by the process. The bottom, *c c*, of the converter, which, like the lining, has to be removed from time to time, and frequently, from the action of the intense heat and the metal resting upon it, is also of fireclay. This bottom, *c c*, which is circular, is perforated with holes, *d*, of from half to three-fourths of an inch in diameter, passing right through from lower to upper side, and in number from sixty up to and over a hundred. Below the circular bottom, *c c*, there is a chamber, *e e*, also circular, and into this chamber the blast is blown by a very powerful blowing machine. The converter is not a fixture, as we in last chapter pointed out: by the aid of suitably arranged and powerful mechanism it is capable of being swung round, to make the mouth describe the arc of a circle, the centre of which is at *f*, at which point it is hung upon trunnions or axles.

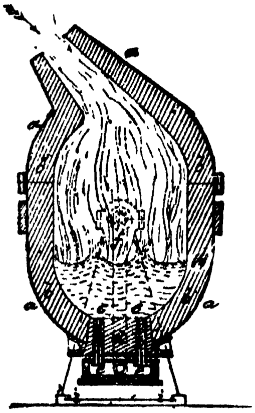


Fig. 1.

THE GEOMETRICAL DRAUGHTSMAN.

His Work in the Construction of the Figures and Problems of Plane Geometry, Useful in Technical Work.

CHAPTER XIII.

The Two Sides of a Triangle being given, and also the Angle which they should form, to describe the Triangle.

Having drawn an angle equal to the known angle; and having carried on each of its sides lengths equal to the given lines, we obtain at the extremity of these sides two points, which we join by a straight line to form the triangle required. Knowing the two angles of a triangle and their adjacent side, to construct the triangle: having drawn the known side, we construct at one of its extremities an angle equal to the first, and at the other extremity we draw the second angle, and thus obtain two new sides, which, in meeting, will form the triangle. We thus see that when we know three of the six elements of a triangle, provided there is a *side* as one of them, we can always construct it. The triangles are of greatest importance, since we can resolve into triangles all other kinds of figures or plane surfaces, and all polygons, as we shall have occasion to illustrate and describe further on. Triangles have one more peculiar property—which is, that however irregular they may be, they may still be inscribed in a circle, since we can always make one of them pass through the three points forming the apexes or points of its angles.

Problems connected with Triangles.

In paragraphs preceding we commenced the problems connected with the construction or describing of polygonal figures, ending with several in connection with the triangle. In view of the importance of this figure, taking it as the first of the class of polygons or figures of many sides, we here give some problems or constructions connected with it.

"To construct a triangle, the three sides of which, *a*, *b* and *c*, are given."—On a straight line set off a length *a b*, fig. 69, equal to any one of the sides given, as *c* for example. From the points *a* and *b* as centres, with openings of compass respectively equal to each of the two other sides, describe two arcs which intersect at *c*: *a c b* will be the triangle wanted. The two arcs of circle will intersect equally at another point *c′*, situated below the line *a b*; but this solution is precisely the same as the above, for the triangle *a b c′* and the triangle *a b c* having the three sides equal each to each, may be equal. It is, moreover, evident that to make the construction possible, one side must be smaller than the sum of the two others and larger than their difference; for, to make the two arcs intersect, the distance from the centres must be smaller than the sum of the radii and greater than their difference.

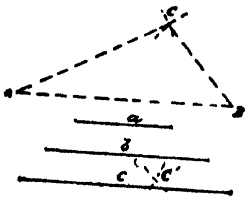


Fig. 69.

"To construct a triangle, knowing two sides and the angle which they comprise or embrace between them."—Make an angle *b a c*, fig. 70, equal to the angle given; on the sides of this angle set off lengths *a c*, *a b*, equal to the given sides *b* and *c*, and join *b c*. The triangle *a b c* is the triangle wanted. There can only be one solution of this problem, for two angles which have an equal angle comprised between sides equal each to each are equal.

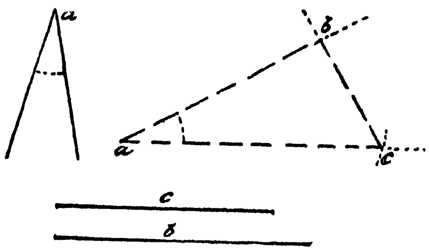


Fig. 70.

"To construct a triangle, knowing one side and the two adjacent angles."—Take on any straight line a length *a b* = *c*, fig. 71; at the points *a* and *b* let us make with this straight line angles equal to the angles given, *a* and *b*. The outer sides will intersect somewhere at *c*, and the triangle *a b c* will be the triangle required.

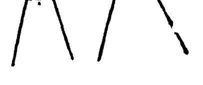


Fig. 71.

"To construct a triangle, two sides, *b*, *c*, and the angle *b* opposite one of them, given."—Make the angle *a b c*, fig. 72, equal to the given angle *b*; on one of the sides of this angle let us carry a length *b a* = *c*. Then from the point *a* as centre, with radius equal to the side given, *b*, which should be opposite to the angle *b*, let us describe an arc of circle which will generally cut the line *b c* at two points, *c* and *c'*. Join *a c* and *a c'*: we obtain thus two triangles, *a b c* and *a b c'*, which have the angle given and the sides given in the position indicated.

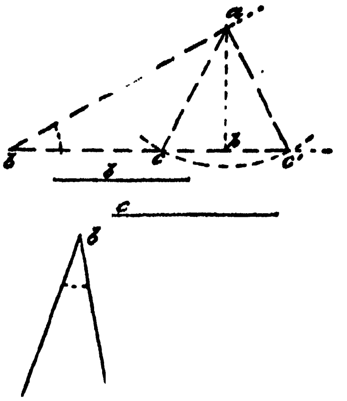


Fig. 72.

Problems connected with the Square.

We now come to the four-sided polygons or quadrilaterals. Of these there are five kinds—viz., the "square," the "rectangle," the "rhomboid," the "rhombus," and the "trapezium." Let us first take the "square." The square is what is called the "regular quadrilateral"; it has its four angles all right angles, and its four sides are equal, as fig. 1, Plate CXLIII.

Its surface is equal to its base multiplied by its height; and as the base of a square is equal to its height, since its four sides are equal and perpendicular two by two, it follows that the surface of the square is equal to its base or to its side multiplied by itself. Consequently we call the "square of a number" the product of this number multiplied into or by itself: thus, 6 × 6 = 36; 36, then, is the "square of 6." We call the "square root of a number" that figure or number which has been multiplied by itself to make the square: thus, 6 is the square root of the number 36.

The square made on the hypothenuse of a right-angled triangle is equal to the sum of the squares formed on the other two sides (fig. 2, Plate CXLIII.). Thus, to find the side of a square, *a h i c*, fig. 2, Plate CXLIII., the surface of which would be equal to the sum of two other squares, as *a b g f* and *c d e b*, construct with the sides *a b*, *b c*, of these latter a right-angled triangle, *a b c*; join the two extremities of this angle by a straight line, *a c*, which will be the hypothenuse of the right-angled triangle *a b c*, and the square *a h i c*, constructed on this line, will be equal to the sum of the two squares, *a b g f* and *c d e h*, constructed on the two sides *a b*, *b c*, of the right-angled triangle *a b c*.

To draw a square the side of which we know, or is given, as *a c*, fig. 2, Plate CXLIII., raise at each of the extremities of this side, as *a c*, perpendiculars, as *a h*, *e i*, of the same length as *a c*; by joining their extremities, as *h i*, the square required is formed as described.

To inscribe a square in a circle *a b c d*, fig. 3, Plate CXLIII., join by lines the four extremities, *a*, *c*, *b*, *d*, of the two diameters, as *a b*, *c d*, which intersect perpendicularly in the point *e*. Each angle of a square, being a right angle, is equal to 90°. It is popularly called a "four square."

We now come to the rectangle. This is a quadrilateral which has four angles all right angles, but the sides are not all equal. It is popularly called a "long square" (see fig. 4, Plate CXLIII.). One of the sides of the rectangle being taken as a base, the height will be the side which is perpendicular to it. The surface of a rectangle is equal to its base, *c d*, multiplied by its height, *d a* or *b c*. To construct a rectangle, the base *d c*, fig. 4, Plate CXLIII., and the height, *d a*, of which are given, first construct a right angle, as *c d a*; make one of the sides, as *d c*, equal to the base of the rectangle, and take the height, as *d a*, as length of the second. Parallel to *c d* and *d a* draw lines *a b*, *c b*, intersecting in point *b*: *a b c d* is the rectangle required. Or from the extremity, *d*, of the side *d c*, forming the base taken as centre, and with a radius equal to the height, as *d a*, describe an arc of a circle; then from the extremity, *a*, of the other side, as *d a*, forming the height, taken also as centre, and with a radius equal to the base, as *d c*, describe a second arc cutting the first; we thus obtain a point of intersection at *b*, which, being joined by two straight lines, as *b a*, *b c*, to the extremities of the sides already drawn, will complete the figure of the rectangle. In every quadrilateral the line which joins the angles of two opposite angles, as *d b* or *c a*, is called the "diagonal." A rectangle is often called a "parallelogram."

We now come to the rhomboid, a quadrilateral which has its sides parallel to each other, but none of its angles are right angles. The parallel sides, as *a b*, *c d*, fig. 5, Plate CXLIII., are equal one to the other, as well as the opposite angles, as *c d b* = *d c a*. One or other of the sides, generally the longest, as *c d*, is taken on the base, and for height the perpendicular raised on this base, as *d c*, or on its prolongation, as *c d f*, to the opposite side which is parallel to it. The surface of the rhomboid is equal to its base multiplied by its height.

To construct a rhomboid we require to know one of the angles and the two sides between which it is comprised. This angle being drawn, after having given to the sides lengths equal to that which we have given from their extremities, parallels are drawn to the opposite sides; these straight lines in meeting will form the rhomboid.

THE SANITARY ARCHITECT.

THE PRINCIPLES AND PRACTICE OF HIS WORK, IN HEALTHY HOUSE ARRANGEMENT AND CONSTRUCTION.—TECHNICAL POINTS OF SEWERAGE AND DRAINAGE, VENTILATION, ETC.

CHAPTER VI.

WE stated at the end of last chapter, that while we give to house drainage all the credit of being a most important part of practical sanitation, there are nevertheless other departments which fall to be considered. These, though not altogether neglected, if carried out in a more or less incomplete way, will be sure to bring about a state of matters promotive of bad or unsatisfactory health, and this in proportion to the extent to which inattention to their details is given. We have already seen that dampness in houses—chiefly caused by neglect of certain points connected with the site or soil of a house, and of certain details in construction of walls—is a prolific cause of bad health. We shall see, as we proceed, that there are other departments of sanitary house construction which, if neglected, will also give rise to bad health in the inhabitants of the dwellings so defectively arranged and built. The truth is, that while some departments of house sanitation do assume, or have given to them, an importance denied to others, and are, in truth, of the highest value as factors in securing a satisfactory solution of the problem how to build, arrange, and maintain healthy houses for us to live in,—it may be said that, in one sense, all the departments are of equal importance, inasmuch as the neglect of any one of them destroys the efficiency of the work as a whole. At the same time we are, as we have said, quite free to admit that house drainage and sewerage is a department of the very highest importance in sanitary construction. To its details, therefore, we now address ourselves.

Did space permit, we could adduce evidence of a state of matters in connection with the condition of drainage of houses and of districts by no means complimentary to our boasted civilisation compared with things of the past. True, we have naturally done much to bring about a condition of matters more consonant with the true principles of this civilisation; but we are so far from having done all that can be done, that not a few maintain that we have scarcely touched the fringe of the subject. Certain is it, also, that much of the work which has been done is so deceptive in its character as to lead to the definite and certain conclusion that it would, in many instances, have been safer had no attempt been made at all. This seems paradoxical; but it can be easily shown to be strictly true. To understand thoroughly how this can be, the reader will require to study the peculiarities of the modern system of house drainage, which will be fully explained presently. Meanwhile, we may here remark that these very peculiarities open up sources of sanitary evils, placing it in the power of careless, or what is worse, unscrupulous and dishonest workmen, by their defective and, in some cases, wholly neglected work, to bring about the very condition of things—so pregnant with sanitary mischief—which the system they profess to work out is designed to prevent. How far prevention is from being secured by the so-called systems of house drainage—professedly founded upon correct principles—we have but too abundant evidence around us to prove, because the evils are not only existent amongst the houses of the middle classes, they are to be met with in the mansions of the richest. So extensively have the defects of the system of house drainage established themselves, that the following statement by a writer on the subject is not a whit exaggerated. After pointing out more than one noted example of a mansion which, professedly "well drained on the most approved and advanced system," was nevertheless such a fever-producing place that it would have been infinitely more healthy had drainage never been attempted other than that which satisfied our ancestors in the last two or three generations, the writer goes on to say, "Scores of great country houses are even worse; and though smaller dwellings, by limiting the area of evil, are not quite so bad, many of them are in a state which would disgust any one with the most elementary ideas of what a healthy building ought to be." This seems to be but a sorry result of all that has been said in the last generation of the evils of defective drainage, and of all that has been so praised in connection with the new and modern system of house drainage, which was to get rid effectually of those evils. How this modern system, which in theory is right, has got so warped and twisted from its original and inherent principle that its practice is so defective, we shall in due course learn. To the architect and builder it is of essential importance to have, not merely a thorough understanding of what correct principles of house drainage are, but an honest and scrupulous determination to carry those principles into perfect practice.

Importance of House Drainage.—A Good System not universally carried out.

With special reference to one department of sanitary science—namely, that of drainage—how essential to health it is that all the refuse matter of our dwellings be carried off as quickly as possible, and not merely carried away, but so dealt with that no unhealthy influences shall afterwards arise which might otherwise be created through any defects in the system by which the refuse matters were carried away. We have shown how, after long years of indifference to and neglect of the laws which regulate health in this department, great attention was paid to the subject, and efforts on an extensive scale made to apply those laws to the houses of our population. And certainly, if we are to judge from the prominence which has been for many years given to the subject of house drainage, and town—or rather street—sewerage in various ways, such as Government commissions and inquiries, efforts of town corporations, and through the various channels of the press and the platform, to say nothing of the enormous sums spent not merely by corporate bodies, but in the aggregate by individuals, it would be apparently quite safe to presume that the science of house drainage and its resultant practice were so well established that few faults, if any, remained to be found with our action as a people in regard to them.

How far we are, however, after all that has been done in the practice of sanitation, from having established a system of house drainage which has some of the characteristics at least of fixity or precision of principle, we have, as we have said, but too abundant evidence to prove. The point is worthy of being inquired into, if only for the lesson of reproof and of practical warning which the inquiry yields: all the more that the inquiry as to principle would show but too conclusively that our practice is actually as limited in its range as it is wofully defective in its details. For obvious reasons this inquiry cannot be here entered upon, however abundant the materials for it may be: all that we can do is simply to glance at its leading features, and these for the present bearing chiefly upon the fact that a very large percentage indeed of the work of house drainage which has been executed during the last few years is so eminently defective that all which can be said in favour of the systems in vogue is, that they have only attempted to do the work. And further, as a final and assuredly a most miserable result, this attempt having so extensively failed, a very large proportion of the work of the past few years which has been declared to be, has been only apparently done.

To prove that we are not in any way exaggerating the actual position of matters as affecting the way in which house drainage has been carried out, one has only to glance at the leading papers which have been read from time to time within the last two or three years before our learned and scientific societies on the general subject. Nor less striking in their evidence are those reports of special inquiries into cases which, from one cause or another, gained at the time a somewhat unenviable notoriety. When we read such statements as the following—made, be it remembered, by authorities who can lay a high, if not the highest, claim to a thorough acquaintance with the subject in all its details—we are compelled to conclude that there must be some cause not yet fully and clearly grasped by us as a people for a state of matters so eminently unsatisfactory, either from a scientific or a practical point of view. And in this connection it is to be noted that the grave faults — they could scarcely well be graver—with which our practice of house drainage is charged are not found to be existent in connection with houses of the poorest and middle classes only, but are met with in those of the highest classes —the residences of royalty, and the great halls and mansions of our nobility and wealthy men. This aspect of the subject lends still greater gravity to it; for if the buildings of those who can afford to have the best work, surrounded by health and comfort, fail to receive it, what chance is there of its being given to the houses, we do not say of the poor, but of the middle classes? Take, for example, the statement, made by an eminent authority, that of five hundred first-class mansions which he examined in London, so deficient were they in the requirements demanded by a good system of house drainage that even the best of them "failed to meet the requirements of a thoroughly healthy dwelling." Still more striking would be the contrast between what ought to be the characteristics of a house really healthy in its arrangements, and what ought not to be, if we examined the details of the report concerning a mansion of the first class, costing some forty thousand pounds, and which had expended upon it a very large sum specially for drainage purposes, and yet which proved to be, not merely incomplete—that would have been bad enough—but so thoroughly subversive of or antagonistic to all the sound principles of the science, that the mansion, in place of being freed from the malarious and disease-engendering influences arising from defective drainage, was, on the contrary, so thoroughly supplied with them, that the actual and practical result of the examination which was ultimately made was the decision that the mansion was literally a pest-house of disease. If, with all the pecuniary means at his command, and with all the ingenious details by which his "system of drainage" was carried out, the architect of this costly mansion failed to secure a healthy, and managed to obtain a thoroughly unhealthy house, what chance does there seem to be of obtaining well (that is, healthily) drained houses, when these are constructed with the limited means of the great majority of those who build houses for themselves, and who, obviously, at least wish to have healthy houses for their homes?

Importance of Good House Drainage *(continued)*.

Taking, however, the features of the practice of house drainage in general, some conception of its condition may be gathered from the statement of one of the highest practical authorities on the subject, that of the "thousands" of drains which, in the course of only the past seven or eight years, he had practically surveyed or examined, only "three" were really perfect

—a percentage so small that we can name no fraction easily read which would represent it—it would, in fact, be almost the literal truth to say that the whole were defective; and that the defects ranged from the moderately up to the thoroughly and in every way bad, there is good ground for believing. And there is also but too good reason to conclude that this statement, so thoroughly depressing to all those who, from what had actually been done in drainage, had hoped for better things, may be taken as descriptive of the condition of the question in every district of the kingdom. And if this view be in the main correct, our practical position in regard to the service and practice of house drainage would appear to be this: That a new departure will have to be made. For if there be any truth in the statement that the health of the inhabitants of our houses is dependent greatly upon the way in which their refuse matters are effectually got rid of, it is obvious that a practice so defective as that which all evidence goes to show exists widely amongst us is worse than a practice which would ignore the necessity of drainage altogether, inasmuch as it is practically a delusion and a snare, leading people to believe that they are safe from the attacks of the evil influences of defective drainage, while in reality they are placed under circumstances in which those influences are in daily operation, though unsuspected; whereas, if nothing were done, or at least only in the simple tentative way which satisfied our forefathers, nothing—or, at least, not much—would be expected in the way of prevention. In house drainage, as in other matters, concealed or unsuspected sources of mischief are really more dangerous than open causes, which possess this great advantage—that the evils are at least known. One may decide that it will be easier, at least cheaper, to do nothing to get rid of those evils; but, if so, the risks are taken open-eyed. But it is a double injury which is inflicted when one undertakes to give an owner of a house a system of drainage which makes a great pretence to thorough efficiency, but which, in place of having any true claim to this, brings about actually a condition of matters in many respects worse than that arising from doing nothing, inasmuch as the sources of evil are unknown and unsuspected.

House Drainage: Its One Principle.—Many Ways of carrying it into Practice.

That this eminently unsatisfactory condition of the important question of house drainage does not arise so much from defects in its theory or science, but much more from the way in which its practice is carried out, seems to be pretty well established. The mere statement of first principles, or the science of house [illegible], can be given, as we shall hereafter give it, in some half-dozen words or so. And on these principles systems have been based so numerous that their name may be said to be "legion." Taking those generally, no great harm is done to their authors when we say that if there had been fewer of them, more would be done in the future, more would have been done in the past. One evil certainly does arise from this multiplicity of "systems." Each one has, of course, its warmest advocate in its inventor, and he may be backed by friends more anxious to assist him than discreet in the way in which they do it. This would be well enough if confined in this direction; but to make out their own system to be thoroughly good, it seems often necessary that they should be equally—generally, however, infinitely more—zealous to prove all other systems to be thoroughly bad. In view of this war of opposing systems, it need not be matter of surprise to know that owners of house property and their architects or builders alike are, so to say, at their wits' end to decide which of the systems is the best to be adopted. And if they give close heed to what the advocates of each system maintain should be done, they will very naturally decide to do nothing, or at least but very little; falling back, in extenuation of their total or partial neglect of any system, upon this: that they cannot tell which is right—for "who can decide when doctors disagree?" It does not seem true, therefore, in this matter of house drainage, that "in the multitude of counsellors there is safety." Rather, indeed, is the proverb exemplified that the "safety of the patient lies in the disputes of the physician"; for while sanitarians are quarrelling over their systems, many decide to do little or nothing, thus avoiding, as they assuredly do, the great expense which the adoption of some systems at least would involve, and in some instances a result more disastrous almost than doing nothing at all.

The Primary Perils of House Drainage Work: Careless Work.

While this is so far true of systems generally, which are often vastly too elaborate to be practically successful, it may be said with perfect safety that it is in the practical details of house drainage that the gravest faults are to be found, and which give rise to the most serious evils. No matter how simple and perfect,—and simplicity and perfection as a rule go together,—if the details be not executed properly in the actual working out of the system, it will assuredly fail. We admit freely enough that some injury has been done to the cause of sanitary science generally, and to that department of it which is concerned with house drainage, through the multiplicity of systems, which have had a tendency to bewilder rather than to help those anxious to carry out practical plans.

THE STEAM ENGINE USER.

The Different Classes of Engines used chiefly for Manufacturing and Agricultural Purposes.—The Leading Details of Steam Engines—Constructive and Operative.—Their Practical Working and Economical Management.

CHAPTER XVIII.

At the conclusion of the preceding chapter we commenced the description of fig. 44: continuing this, we have to say that steam is admitted at *a* into the chamber *b*, whence it is admitted, as shown in the drawing, to the upper end of the cylinder, tending to force the piston downwards. The steam which had previously pushed the piston upwards now finds its way into the separate condenser *c*, where it is met by a jet or spray of cold water, and is immediately condensed to such an extent that a vacuum is at once formed, tending to pull the piston downwards by suction. As the water collects at the bottom of the condenser, it is drawn away through the foot valve by means of the air-pump *h*, and pumped into the hot well *l*, and prevented from returning by the delivery valve there shown. This water, which is hot, is pumped into the boiler, thereby saving a considerable amount of fuel. In order that the condenser may be kept cool, it is immersed in a large tank or cistern kept supplied with cold water. In the drawing here shown, the engine is used for pumping, and as the water is brought to the surface it is delivered into the cistern as shown at *r*; thus a constant supply of cold water is kept around the condenser, so keeping it always cool. The cylinder is by this means kept free from the cooling influence of the cold injection water, and, as an inspection of the drawing will show, is kept hot by a steam jacket, shown by a dark line in thickness of metal at sides, surrounding it, supplied with "live" steam, thus keeping the steam as hot as possible whilst exerting its power in the cylinder, till the time arrives for it to be condensed.

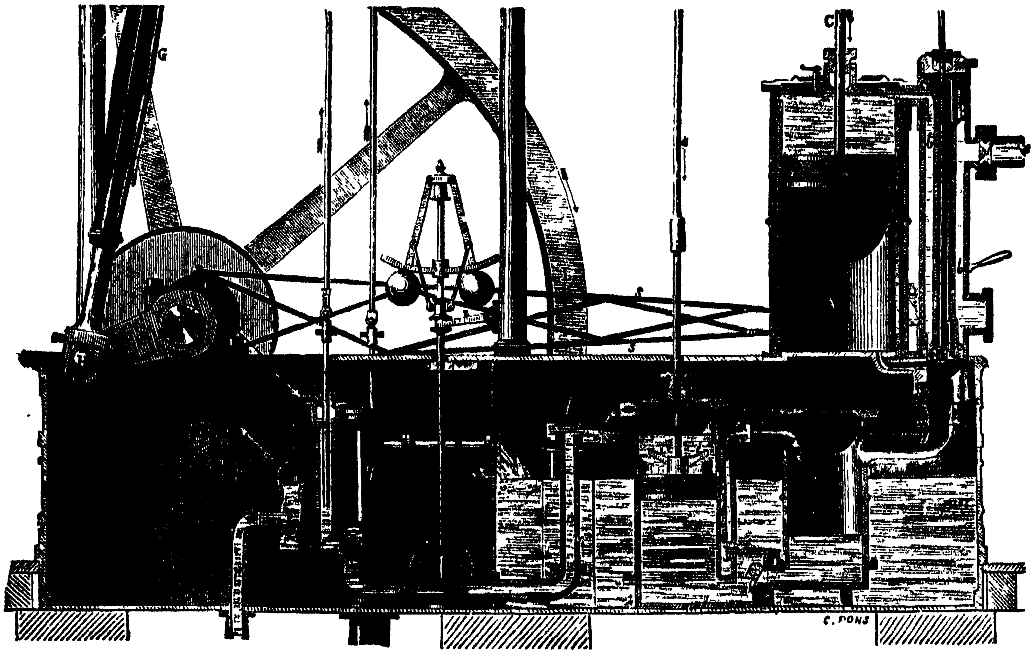


Fig. 44.

Watt also invented another form of condenser, in which the steam was made to pass into a vessel containing a number of small tubes, through which a constant supply of cold water was passing. The hot steam was thus brought into contact with a large area of cooling surface without being actually mixed with the water, merely becoming condensed by the low temperature of the metal tubes. A small model of this is to be seen in the Watt collection at the South Kensington Museum. The idea of a separate condenser is considered to have been Watt's grandest invention, and to have done more to make the steam engine what it is than any other improvement.

The *Connecting-Rod* is the lever which is attached to the end of the beam of a beam-engine, and to the crank-pin, thus connecting the motion of the beam to the crank-shaft. In fig. 25 the connecting-rod there shown is a cast-iron one. In the early forms of engines, of which fig. 22 is an example, chains are used, as the only direction in which power needed to be applied was that of pulling—for the piston was pulled upwards by the weight of the pump-rods on the other end of the beam, which latter was in its turn pulled down through the medium of a chain.

Then, when a vacuum was formed below the piston, the beam was pulled down at that end, whilst the other end was raised, pulling up with it the pump-rods and column of water. Thus it will be seen that there is only a pulling strain, and that a chain, therefore, does the work just as well as a rigid rod; but when the crank was applied to the engine, and a reciprocating motion set up, it was necessary to have a connecting-rod which would both pull and push, so a rigid rod was substituted for the chain. Cast iron being considered the most easily formed metal, this was used, and no doubt did its duty very well, especially as much was not required of it, as only slow speeds were necessary in those days. The rod was cast in different forms, but one of the most usual patterns was that shown in fig. 44, which, if cut through at the point G would show a cross-shaped section. The ends were cast in one piece with the rod, and openings were left into which were fitted the brasses held in place by cottars.

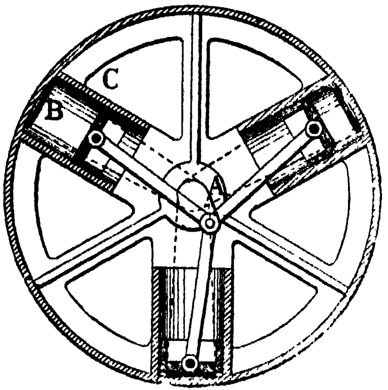


Fig. 45.

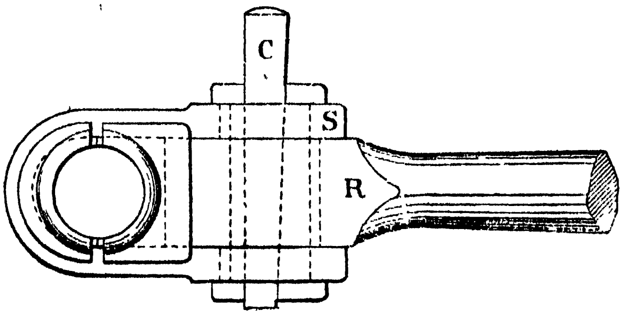


Fig. 46.

The crank shown here is a cast-iron one, most probably. There are various other forms of connecting-rod ends, the most common form of which is shown in fig. 46. It will be seen that the brasses are held in position by the strap S, keyed to the end of the rod R by an arrangement of gibs and cottar. As the brasses wear, the cottar C is driven farther in, which has the effect of drawing the brasses closer together, and thus making them clasp the crank-pin or journal more tightly. Another form, sometimes used in land engines, but more commonly in marine engines, is that shown in fig. 47. The end of the rod is in the form of a cross, and the brasses are held together by the two bolts and cap, as illustrated. This is a very simple and at the same time strong arrangement. A space is left between the brasses to allow of tightening up in case of their becoming worn.

Cranks.—As mentioned before, cranks are sometimes made of cast iron, and sometimes of wrought iron. A cast-iron crank is shown in figs. 48 and 49, the former being a section. It will be noticed that there are two ribs cast on the crank, so as to make it of a trough section, as shown at A. Sometimes a cross-shaped section is adopted, as shown at B, but this form is not so strong as the other, though it has the advantage of being easier to cast. The crank-pin is sometimes cast in its place and turned up afterwards, but generally it is made separately, shrunk in and riveted afterwards. The crank-shaft is turned to fit the opening at the other end, and a key driven tightly in prevents the crank from turning round upon it, half of the key being sunk into the crank and half into the crank-shaft.

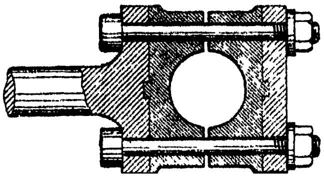


Fig. 47.

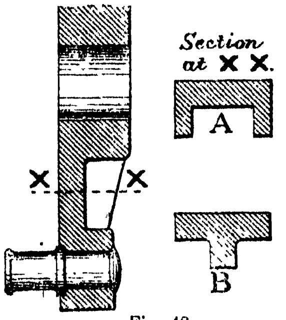


Fig. 48.

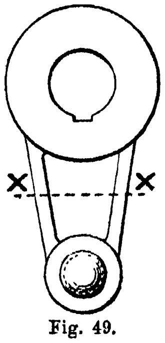


Fig. 49.

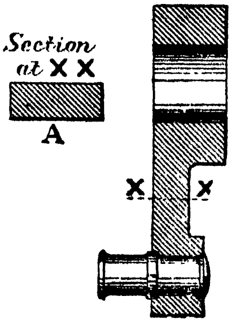


Fig. 50.

THE ROAD MAKER.

HIS WORK IN THE LAYING OUT OF ROADS IN RURAL, SUBURBAN AND TOWN DISTRICTS, THEIR CONSTRUCTION, REPAIR, AND IN THE CHOICE AND USE OF THE VARIOUS MATERIALS EMPLOYED.

CHAPTER IX.

CONTINUING our description of the drainage of roadside or foot path commenced in last chapter, and referring to the illustration here given, fig. 16, we have to state that the surplus water of the side drain *c* is then carried off to the ditch *f* by the tubular drain *e e*. This runs through the soil below the footpath *d d*, and being placed at intervals along its length, the side drain *b c* running along the whole of this, the soil under the footpath at or near, as well as in the intervals between, will be drained more or less efficiently by the cross drains *e*, *e*, as well as in some measure by the near side of the open ditch *f*.

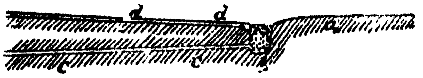


Fig 16.

A more efficient arrangement is shown in fig. 17, in which *a* is part of the main road, *b* the stone-filled side- or footpath gutter drain, into which the surface water of the footpath *f*—*g* being the fence of quickset —drains. The surplus water of the drain *b c* is not in this instance carried into an open ditch, as at *f* in fig. 16, but is led by a tubular drain, *d*, to a side tubular drain at point *e*. This should be of large dimensions, so as to act as a drain of the water not merely from the land outside the road *a*, lying towards the left of *e*, but also as a further or additional drain to the soil to the right, even that under the body of the main road. Well constructed drains draw supplies of water from a much wider area than is generally supposed; the width of the area depending, of course, upon the nature of the soil. A heavy soil lying compactly together will be drained throughout a less area than a light and loosely lying one. Another arrangement is where the gutter drain from the footpath is outside the path, the surplus water being carried down by a pipe to the side tubular drain.

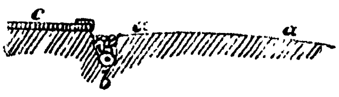


Fig. 17.

Side Gutters of Footpaths.

We have alluded to the importance of having the side gutters kept free from the grit or detritus washed into them from the surface of the road and footpath. In fig. 18 we give a section at *a a a* showing arrangement for a single trap "gulley" or side drain. The bottom of this should be rounded so as to afford facilities for clearing completely out the detritus or gritty sediment. The grating or "grid" at line *b*, shown in section at *f g h*, is placed below the road curbstone *d*, some distance from its upper surface, the level of the curbstone *c* of the footpath being a little lower than that of the curbstone *d*. The surplus water is carried off by the pipe *e*—this having the same relation to the trap and to the footpath surface as the tube *e*. fig. 19.

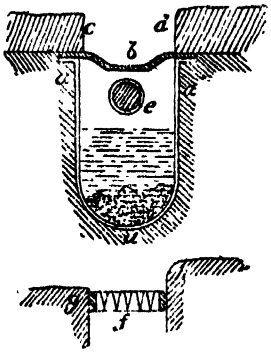


Fig. 18.

As the detritus or gritty sediment held in the drainage water falls to the curved bottom of the trap it is apt to concrete together or solidify into a mass very difficult to remove, especially in dry weather. And as much of it is unfortunately carried over into the drain, tending to choke and fill it up, it is a good plan to prevent this untoward effect. This may be very effectively done by using the double trap shown in fig. 19. Any sediment or silt that fails to be deposited in the first gutter, sides of which are shown at *a a*, will almost certainly be deposited in the second, *c c c*, grid of which is at *d*. The surplus water will then pass off to the drain by the tube *a c*, comparatively free from deposit. Some such plan as this to prevent the gritty, concrete, fine material from entering the drains, which has such a decided tendency to choke them up, although expensive at first, will be cheaper in the long run, and save much after-labour. The cost of making covered roadside

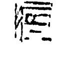


Fig. 19.

drains for subsoil drainage of the road with 2-inch tubular drains has been estimated at £36 5*s.* per mile, and with 3-inch drains at £42 17*s.* Where the surface water is also to be taken, the cost would be increased. In fig. 20 we give a suggestive hint for forming the side gulley traps of roads and their footpaths in a much less expensive way than when they are constructed specially of brickwork. It is of course understood that while the main body of the gutter runs alongside the road or footpath throughout the whole of its length, the traps for arresting the detritus, as in figs. 18 and 19, and the one now to be described as in fig. 20, are only placed at intervals along that length. The more likely the traps are to be speedily filled—the general nature of the climate deciding this—or the worse the character of the detritus washed into them as a concrete-forming material, the more frequent should be the "traps" for arresting that detritus. The "trap" in fig. 20 is made out of a large sewer drain-tube, *a a*, the lower end, *b b*, of which is fixed in and surrounded by a mass of fine clay or of concrete cement, to make the foot a watertight receptacle. The sewer tube is of that class, having at upper end a faucet joint *d d*, and a side branch tube *e f*, this acting on the tube *e e*, fig. 20, to carry off the surplus water to the drain.

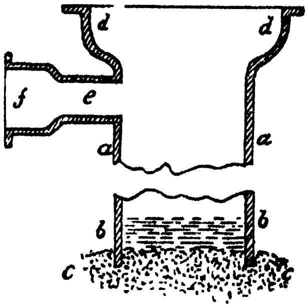


Fig. 20.

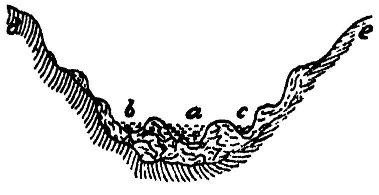


Fig. 21.

On the construction of large open watercourses for the conveying away of flood water, the contents of the main drains of fields or the water from roadside drains, we may offer a few remarks.

In dry weather the water in these open ditches moves along the bottom in shallow streams, or lodges thereon in small stagnant pools, as at *b* or *c*, fig. 22. In addition to being thus so far useless for the very purpose for which they are intended—namely, the rapid conveying away of the water—an unhealthy condition is created from the emanations arising from the stagnant water, as at *a b c.* In place of resorting to the expensive method of arching over these watercourses, the following method has been adopted with complete success:—Below the bed of the natural watercourse, *a b c d,* fig. 22, a tubular drain *e*, or as at *e f g h,* is placed, and covering over the tubular drain when laid, care being taken to provide, where necessary, junctions for side drains. The bed of the stream being re-formed with clay and gravel so as to form a better channel, such flood-water as could not be conveyed by the pipe beneath is taken in this bed. In this way a better fall is got, the flow and the sweep of the water accelerated, and comparative cleanliness and salubrity is obtained, at from one-eighth to one-fourth the expense which arching over would have taken. Where this method has been carefully adopted, so much has the flow through the pipe been accelerated, that there are comparatively rare occasions when there is an overflow from them, and the surface of the drain presents the appearance of a clean narrow road. Modifications of a simpler and less expensive character of this plan may be made, and yet with great advantage to the road. Thus, in place of the drain tube, the lower part of the ditch may be re-formed as at *a*, fig. 23, this hollow being filled with stones up to the line of *b*, the sides *d b*, *c b*, being also made straight.

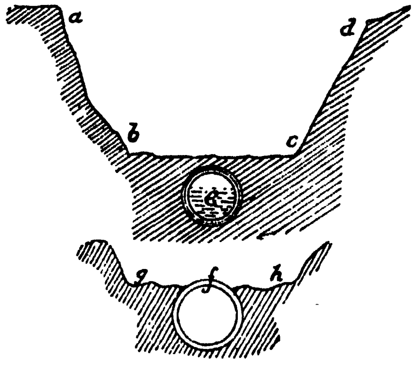


Fig. 22.

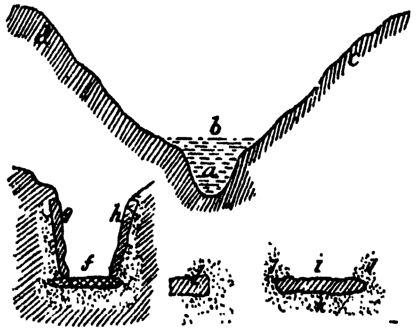


Fig. 23.

THE FARMER AS A TECHNICAL WORKMAN.

His Tools, Implements, Machines and Materials. —The Principles of his Work in its Various Departments.

CHAPTER VIII.

If we compare the seed of any well-known farm plant, as wheat or a turnip, with the ultimate produce, we must be struck with the vast increase in bulk and weight which has been secured in the new form of the produce. In the case of wheat we see from a single grain how many grains of the same kind are obtained. We have obtained from one as many as a hundred,—in some few instances an increase in number considerably higher than even this high figure of increase. And on comparing the weight of the ultimate number of grains with that of the original grain, the contrast is all the more striking. This point of weight is perhaps more striking still in the case of produce of seed other than that of wheat—such as the turnip. Here, while we have no multiplication of units, only one turnip proceeding from one grain of seed—unlike the wheat, which, as we have seen, gives many grains from one—we have a still more marked increase in weight and bulk. The increase of bulk alone is a special feature, for the tiny seed grain, a mere fraction of an inch in diameter and of a cubic inch in bulk, is changed to a root which is many inches in diameter and many inches in cubical capacity. In saying that in the case of a turnip there is no repetition of the seed, we mean only in that part of the resulting produce which is used as food. In point of fact, there is in both the wheat and the turnip, as indeed in all seed-bearing plants, an intermediate product: in the case of the wheat, the straw comes between the seed root and the seed produce; in the case of the turnip, the bulb or root comes between the seed root and the ultimate produce of seed. The difference between the two plants, considered as food producers, is, that in the case of the wheat it is the seed or grain which is the primary produce or food, the intermediate part —namely, the straw—being secondary; while in the case of the turnip it is the intermediate product which is retained as food, the seed being only secondary. But if we take both the intermediate and final products, the contrast in weight and bulk of both with those of the original seed is still more striking.

Points connected with the Gradual Increase of the Bulk of Plants.—Their Food Sources.

Where does all this increased bulk and weight come from? Let it be remembered (what is too often forgotten) that the seed has in itself no creative power while certain conditions are absent. So long as they are so, the seed may moulder and decay, but it will not change its form, or increase in bulk or weight. But placed under proper conditions in the soil, those changes at once commence which result ultimately in repetitions of the original seed; the contrast, as we have seen, in the number, weight and bulk of which, as compared with the original tiny and single seed, is very great. Where does this increase come from? It must clearly come from sources foreign to the seed. Those sources we have already indicated as being present in and derived from what are called the fertilising sources or resources of the soil and the atmosphere. The compounds or combined substances or chemical agents and reagents—organic from the atmospheric (as the air) or other fertilising sources (the rain and dew), inorganic from the soil—are by a curious process, part only of which science has as yet been able to grasp, some points of which, with all its power, it clearly can never explain, taken up and assimilated by the tissues of the seed, or emanating from it and made an integral part of it, and give out ultimately the ripened produce we generally designate as food. The inorganic elements demand from the soil but a comparatively small proportion of the weight of the ultimate product—from 1 to 12 per cent.: wheat, for example, having in 100 lb. of the grain only 1·18 per cent. of inorganic matter or incombustible ash, and of the straw 3·51 per cent.; oats yield a higher per-centage of ash in grain and straw, in 100 lb. being 2·58 and 5·74 respectively. The inorganic compounds derived from the soil being taken up in small proportions, but still being essential to the life and growth of the plant, should be as uniformly distributed as possible throughout the soil in which the plants grow, so that all shall have their due share. Hence the value of mixing of soils; and, as we have said, there is practically no soil in which the fertilising constituents are equally diffused throughout it. Hence, also, the value of depth in the soil from which plants can derive their nutriment, so to call it. Now, this nutriment is not only unequally diffused throughout the soil, but it may be presented to the plants in such a condition that, while superabundant in quantity, in condition it is such that there is no affinity, so to phrase it, between it and the plant tissues or rootlets, and they cannot assimilate the nutriment presented them. Thus it is a curious fact that two substances may be applied to a field, one of which will promote, the other actually prevent vegetation; and yet the one substance so preventing it will actually contain three times as much of a highly valuable and essential element of fertility as is possessed by the other substance, which is found to promote vegetable growth.

Character of the Work to be Done by a Cultivating Implement, in order to Aid Plants in Assimilating Fertilising Constituents.

What the farmer, therefore, has to look to the mechanic for is that he shall give him an implement or implements which will enable him to prepare his soil so that it will aid the assimilation of the fertilising constituents present in it by the rootlets or tissues of the plant: in other words, so to place these constituents physically—or in a mechanical condition—and chemically, that they will in the most effective way be taken up by the plants. This is really the essential point required to be aimed at securing,—neither the farmer nor the mechanic to whom he is compelled to go for help in this matter need concern himself about the amount of fertilisers *naturally* present in the soil. The two need not trouble themselves with the grave statements and solemn warnings of some as to the exhaustion from the soils of our country of the fertilising constituents which a continuance in the established methods of cultivation will, they say, inevitably bring about. It may be so, and so far we are disposed from one point of view—indeed, compelled—to admit this; but the remedy is not far to seek. It is to be found in the establishment of a proper system of cultivation, which will enable the farmer to avail himself of the hidden, unavailed-of stores of fertilisers present in nearly all soils—in some rich beyond all the necessities of plant life—in nearly all of them practically inexhaustible. But cultivation proper, as a rule, as yet has not touched this supply, simply because "cultivation proper," as a rule, has yet to be established. And we are profoundly impressed with the conviction, derived from a somewhat patient study of the whole question in its mechanical and farming aspects, and a somewhat careful examination of what mechanism has yet done, and of thought as to what it can yet do, that it is to steam-wrought mechanism that the farmers, and through them the nation, have to look for a great extension of the food-producing powers of the soils of Great Britain.

Some Suggestive Points connected with the Chemistry of the Soil, as aiding the Farmer and the Mechanic in Devising a Good System for its Cultivation.

And in his attempt to avail himself of all the powers which this will afford him, to make available the now locked up stores, of soil fertilisers, it is curious, and so suggestive as to be worthy of special notice, that in this attempt the farmer and the mechanic will both alike be aided by the natural arrangements wisely instituted by a beneficent Providence. For it so happens that the chemical processes—for they are really such—continually going on within the soil in relation to the seeds and the manure which may be artificially applied to it, are brought about and maintained by a condition of circumstances which bring into play and form active agencies in fertilising substances which would otherwise remain inert, and not be assimilated by the plant tissues. Thus, if we keep up a porous soil the air gains access to it, and acting upon the carbon present in it, converts or changes it into carbonic acid, which is a most powerful agent in turning many substances present in the soil, or in the manure given to it, into active fertilising agents, which would otherwise remain dormant or inactive. And of the chemical agents present in the soil, which act the most powerfully in this way of placing fertilising agencies in combination with the soil, so that they can be availed of by the plants, it is to be remarked that they possess their value in a regularly descending scale, the relation to one another and the value of each never varying; and that while they have the power of exchanging their bases, forming new compounds of a valuable character, this power is always exercised in a certain prescribed order, bearing a direct relation to their relative value. And thus the curious fact remains, that while the substances of higher value, as ammonia, can "dispossess," so to say, any of lower value, such as soda, which is the lowest in value of those substances here referred to, the substance of lower value can never "dispossess" that of a higher value. A beneficent arrangement this, and one greatly facilitating the labours of the farmer and the mechanic in making available the hidden stores present in soils; for we thus find "that the more valuable compound shall *always* have the power of displacing the less valuable, while the inferior is restrained by impassable barriers from supplanting the superior compound." Now, when we state the fact, which is beyond doubt, that this transformation, so to term it, of inferior chemical agents present in the soil into superior, which exercise the highest fertilising influence on plants, is greatly aided—indeed, in many cases brought only about—by having a porous soil, the farmer's mechanic will see how necessary it is that he should so design and construct his mechanism that it will give this quality; and, further, as bearing upon this and the other points we have either already noticed or have yet to notice, the necessity which follows as a corollary in consequence of the above, of having the greatest possible depth to the stratum of porous soil. It is not easy to define what the limits of this depth should be. It cannot be too deep: certain it is that our mechanical power of deepening the porous bed will, for some time at least, till greater improvements be introduced, be far behind the capability required of it, so that if there exists a possibility, of which we doubt the existence, that the porous bed would be too deep, we have not much chance at present of reaching the dangerous point.

THE WORKMAN AS A TECHNICAL STUDENT.

How to Study, and What to Study.

CHAPTER IX.

At the conclusion of preceding chapter we stated that it would have been well for the prospects of technical education had many teachers and students alike grasped the real object and meaning of education, which is to take up facts, and by mutual digestion and assimilation thoroughly to understand them. Once this is done, they are their own, forming as it were an integral part of their system, not dependent upon the strength of mere memory, which in its evanescent nature may have no real strength at all. The facts are easily enough got at. The field of their after observation, both of books and of objects or things, and of men, during their early and especially their later life, will be found to abound with them. The mere faculty to see things as they lie around us, waiting, so to say, to be looked at and comprehended, is with some a gift, with others a habit acquired by patient cultivation. So important is this to the technical student that we shall give a few remarks upon it in a succeeding paragraph or two, which may be worthy of special notice. To form, cultivate, and aim at steadily improving this assimilation of truths and facts, drawing or leading out the powers of the mind to bear upon them, is, in point of fact, technical education. And this, as just said, is effected wholly by the discipline of the mind. The powers of this being led out or educed—("education" from the Latin word *educere*, to lead out), or drawn out, and this steadily and persistently and patiently, will "grow with his growth and strengthen with his strength," till what at first may have been a difficulty becomes at last a matter of comparative ease, and a delight. This discipline of the mind, this educing or leading out of its powers, and this more or less in the way we shall hereafter explain, cannot be too frequently stated or too forcibly insisted upon. It is, in fact, the key of the whole position. Once a teacher comprehends it, once a student is willing to apply it, the battle, so to say, is half won.

Essential Value of giving Thought to the Work of acquiring Knowledge.

He was a wise man who said that the first step to be taken in the education of youth was to get them to think; and that once this habit was established, all the other difficulties connected with special or technical education would rapidly disappear. For it is comparatively easy to teach one who is determined to the best of his capability to think about what he is learning; for it is after all only by really understanding what he is studying that he can gain true, and therefore useful, knowledge. Things studied parrot-fashion are worth only parrot-talk.

We shall see as we proceed that the truths and facts constituting what may be called the intellectual food of the student, numerous—innumerable—though they be, ranging themselves naturally, or being ranged by scientists, under separate departments, are to be easily enough got at; and by the system and discipline above named will be rapidly taken up and as rapidly digested and assimilated. There is no lack of material; what the student has to concern himself with is its selection and the mode of using it. The willingness to acquire and this desire to have knowledge, that is, facts which are truly known, must go hand in hand.

The Mere Desire to possess Knowledge, and the Determination or Will to secure it by Study, quite Different Things.—The Practical Importance of the Distinction.

They are not one and the same thing; it would be well for students if they were—that the desire was always coincident with the willingness to acquire knowledge. This willingness involves determination. When a man wills a thing, the determination to do—"I will that it shall be done"—is the first practical step in the doing of it. The desire may go no farther than the mere expression of it, which involves no exertion; willingness brings with it practical and sustained efforts. To will is to work, therefore. If desire for wealth was all that was necessary, no man would remain poor; but to become rich he must be willing to work, and to work hard. All these are but commonplace considerations, which every one approves of; but the misfortune is that every one does not apply them in actual life and its work, in which they are of primary importance. It would be well for many men if in youth they had taken heed to them.

The Modes or Systems of Acquiring Knowledge.

The facts or knowledge useful to the technical student range themselves under several heads. Each of these constitutes a department, and each should have its regular place and be regularly taken up. These departments may be classified thus:—First, the knowledge obtained from a teacher, or what may be called oral or conversational education; second, that of books alone,—of the class or technical school combined with the study of class-books; third, that of personal observation; and, fourth, that of the mental thinking over of the results of the three first-named. By carefully reflecting upon all he has learned the student can select the truths and facts which will be useful in any particular branch.

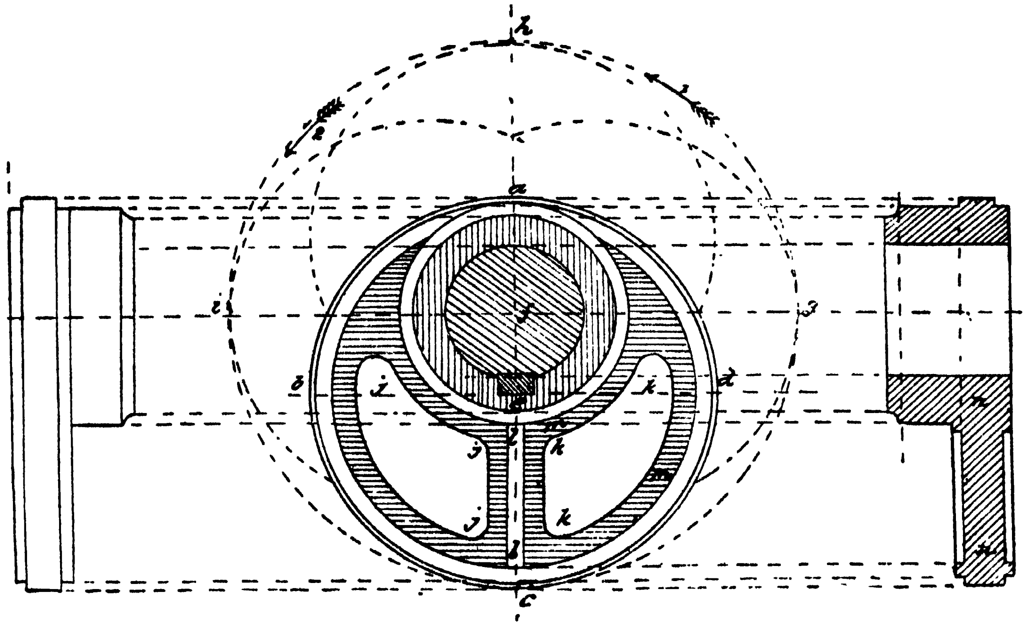
The Relation of the Student to his Teacher.—Value of an Experienced and Wise Friend as a Source of Help and Counsel.

The direct application to the wants and necessities of technical work being the ultimate aim and object of all technical study,—the realisation of preceding hopes and wishes, the fruit or harvest following the pruning of the tree or the sowing of the seed,—in the first of the four classes above named it does not follow that the teacher is always to be the regularly appointed "school teacher," or expounder of the knowledge obtained in the school. On the contrary, a student may have many teachers in friends of the family, or those with whom otherwise he comes in contact, and it will be well for him if he has at least more than one. He may then be taught by those of maturer years and much riper knowledge than he himself possesses, and he should ever be ready to avail himself of such of its treasures as they may be able, and generally are ready and willing enough, to impart. An experienced friend—and unless he be willing at least occasionally, and then frankly and readily, he is scarcely entitled to this honoured name—of this kind cannot be too much esteemed and valued by the student; and, if he be himself wise in his youthful or early days of business, he will be careful to cultivate the acquaintance, and ultimately to secure the friendship, of those who, older than himself, have had wider experience of work and of life, and who have made that experience minister to their will and success. The writer of these lines has had, during a somewhat long life, and an extended experience with many classes, occasion frequently to observe that youths were generally successful in life who had, if not for companions, at least for trusted and often-consulted friends, men much older than themselves. This liking for the company of men of maturer years and riper experience than they can possibly possess is in itself a good indication of the fact that they are, if not positively free, at least desirous to free themselves somewhat from that fatal fault of youth, overweening confidence in themselves: the notion, in fact, which so many of the young possess—although they do not readily own to the fact that they possess it—that they are embodiments of wisdom, to whom might well be applied the sarcastic and suggestive words of Job, "Verily, ye are the people, and wisdom shall die with you." This evident desire on the part of youths who have a liking for men older and more experienced than themselves is, therefore, of good augury for their future success in life. One of the best, and, as they will find it to be, one of the most valuable lessons which it gives, is to look to sources outside of themselves for knowledge of facts, and for counsel and advice. "Self-help" has been lauded enough of late, and we are ready as most to join in its praises, for without it no one can be successful in life; but this extreme laudation has tended, and still tends, to keep out of view the great value of another help in life—"neighbour-help," or "friend-help." The youth who disdains this, and concludes that he is all in all to himself, will have early and bitter experience of the truth that if he leans only upon himself, trusts only to his own wisdom, his own experience, he leans upon a weakened reed, which, breaking, will pierce him with pain and cause him grievous ill. The wise youth will learn to value each kind of help at its true value, and will not be long in discovering—the finding of it out is one of the turning-points in life—that the happy combination is where both self-help and neighbour-help are availed of.

We have said that the value of matured experience of others which is granted to youth by those older than themselves cannot be over-estimated. And by way of encouragement to retiring youths, who may be afraid of being judged as forward, if not vain and impudent, in making advances to secure the friendship of older and wiser men than themselves, we can, from some experience, say, that no good and wise man (wise because good) will repel the advances of modest youth. Far otherwise will the fact be found; he will encourage rather than rebuke; and nothing will more surprise modest youths than in such cases to find not merely the readiness with which they will impart the treasures of their experience, but the obvious pleasure they take in doing so. And although willingly attributing this to the highest motives, we need not lose sight of the facts of human nature met with in life, so that we need not be surprised at this ready willingness of experienced men to be friendly advisers and communicators of their experience to youths who desire to approach them. For as human nature is constituted, there is something pleasing, some might use the term flattering, to one, in being approached at all—as all true men like confidence in them to be displayed—much more if approach be made with an evident desire to gain information; for most men, however humble they may be, feel kindly disposed towards those who thus pay them the compliment of believing that they know much, and have, therefore, much to communicate.

In considering the Question of Technical Education, Men must be taken as they are—Facts as they Exist around us.—Human Nature one of the most Important Factors in the Solution of the Problem.

The student beginning life who reads our various paragraphs must not take the impression that considerations such as these just delivered, and others to which we are about to direct his earnest attention, have little to do with the practical work of technical study. He may at first sight think so, and that all matter of this kind is more concerned with moral than with intellectual considerations. But if he will only in the meanwhile take it for granted that such considerations are closely connected with the subject, and thereafter proceed with us in what we have further to say, we trust to be able to show that they cannot be overlooked, or if neglected, neglected without certain loss.



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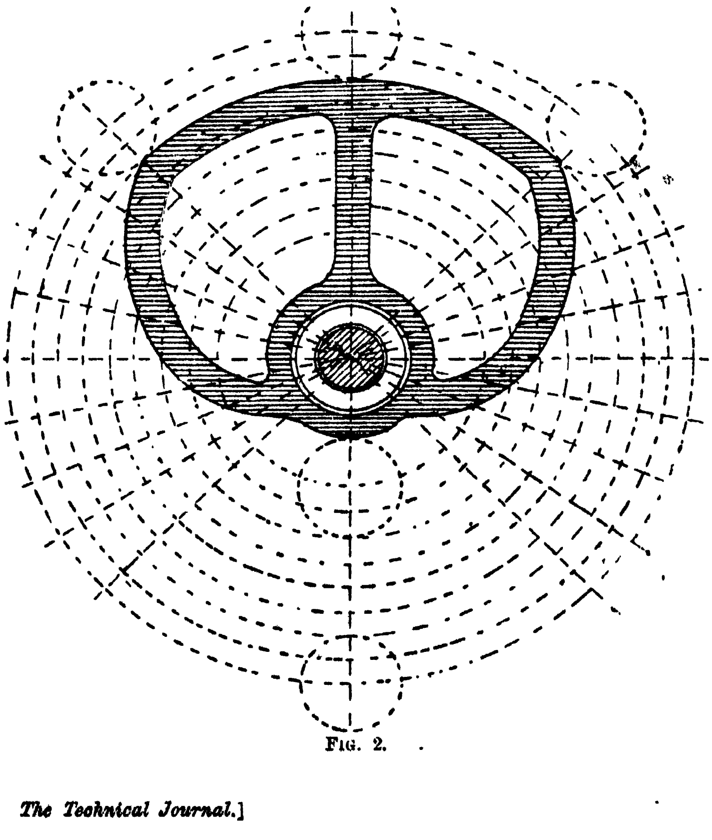

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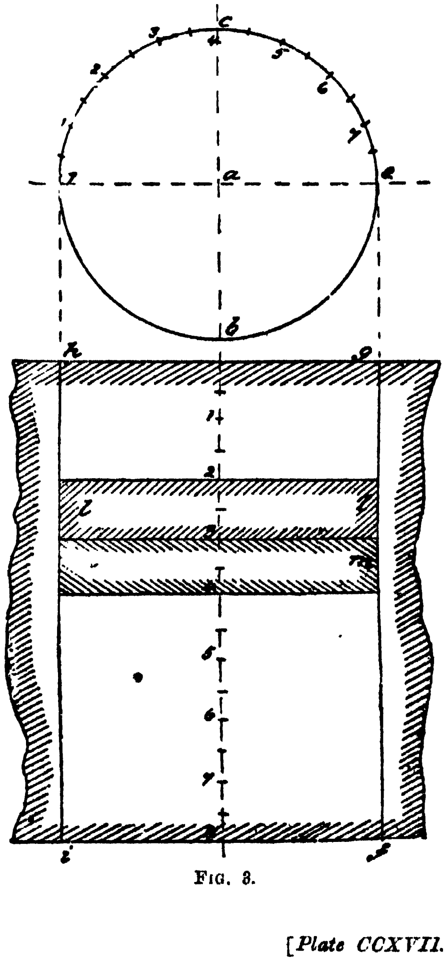

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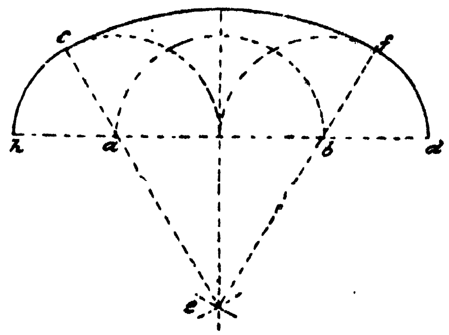

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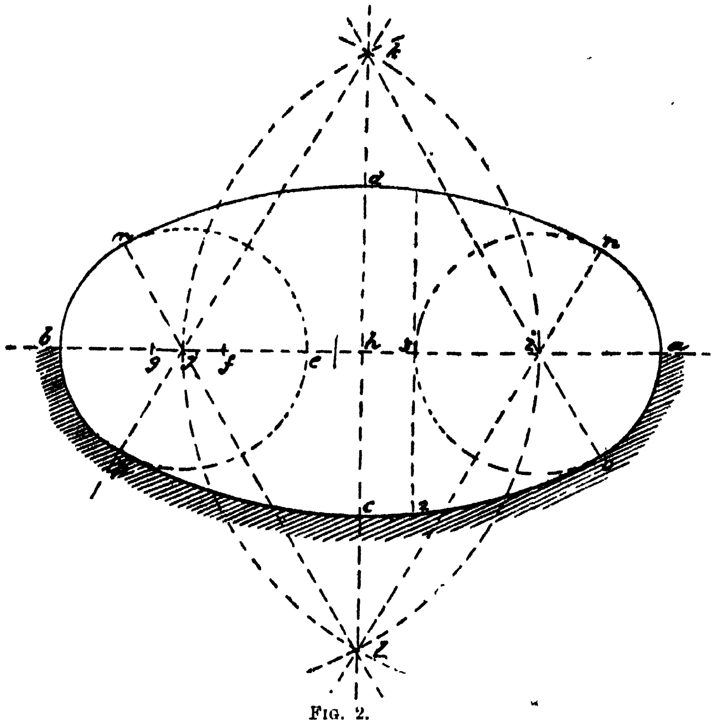

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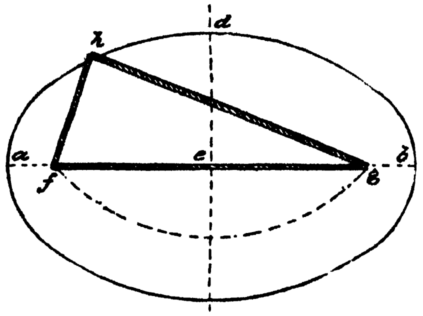

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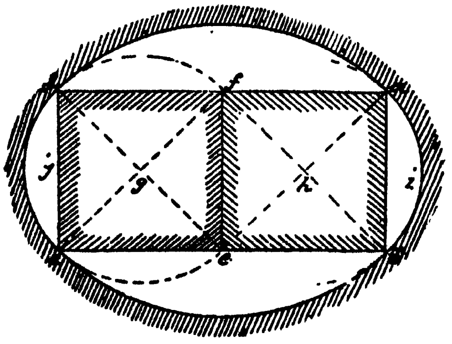

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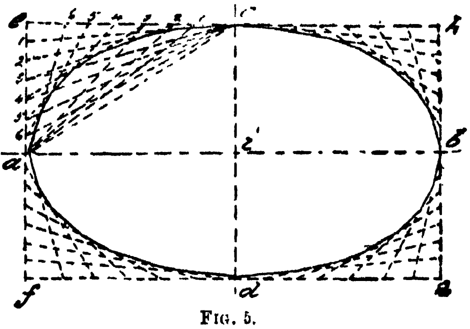

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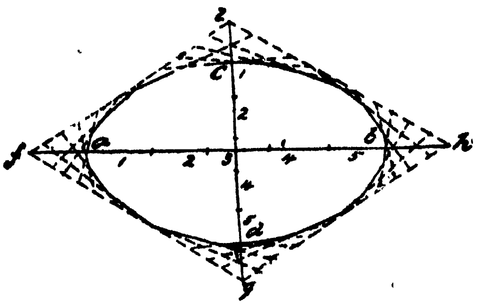

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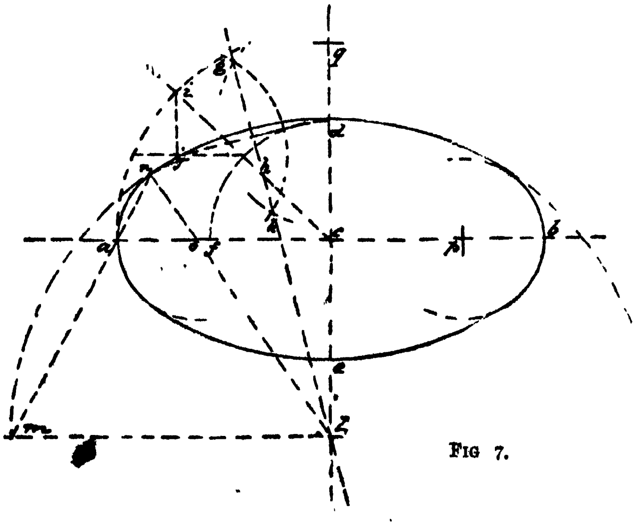
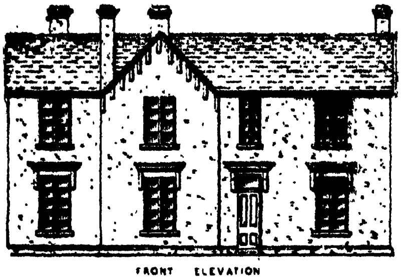


FIG 7.

Detached House, Figs. 1—5.
Row of Four Cottages,



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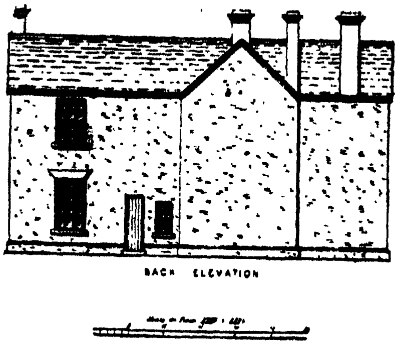

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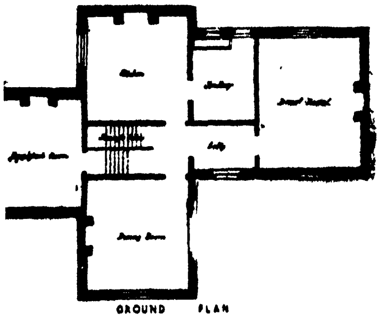

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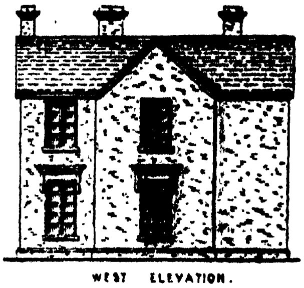

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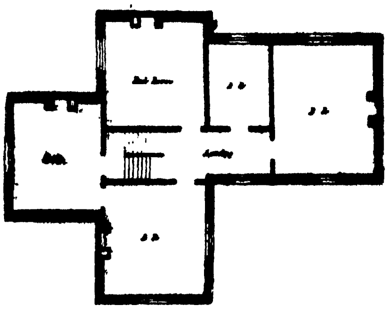

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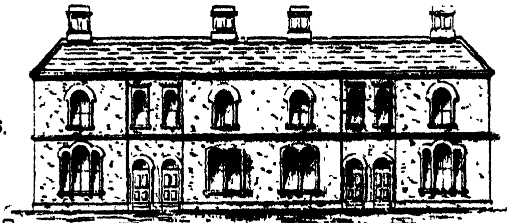

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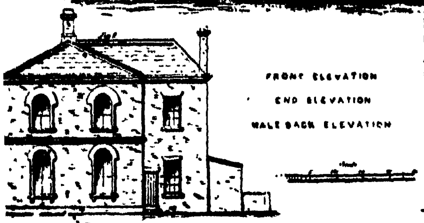

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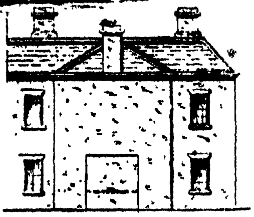

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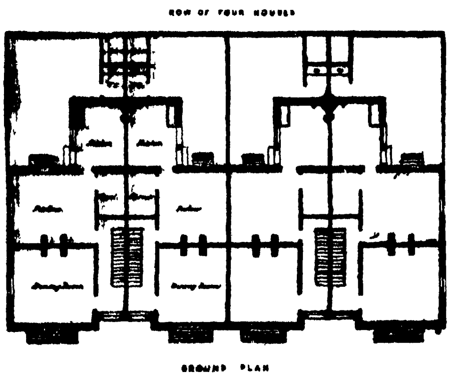

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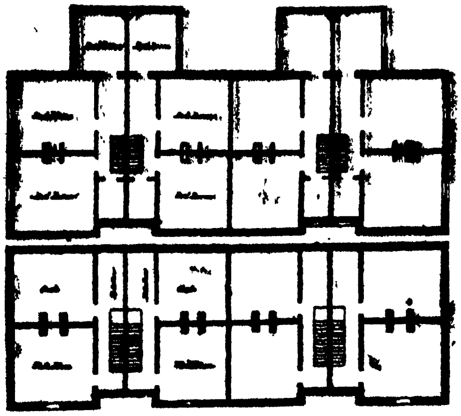
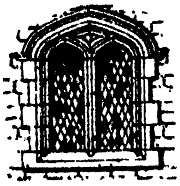


Fig. 10.

THE STONE MASON.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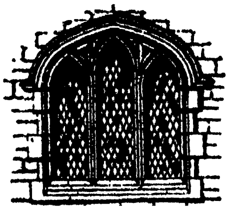
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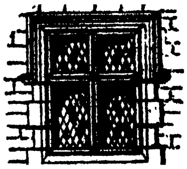
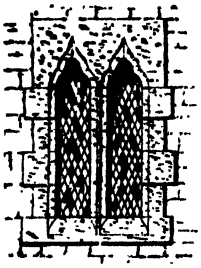


FIG. 3.

GOTHIC WINDOWS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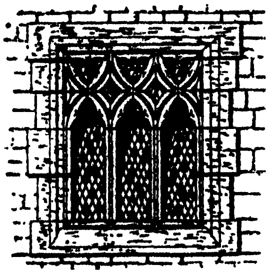
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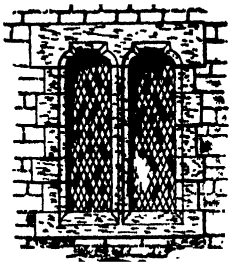

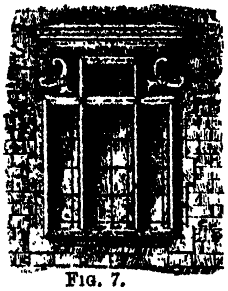
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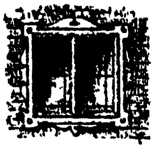
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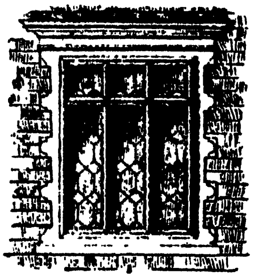
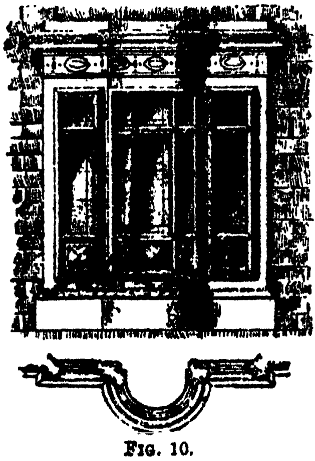


FIG. 9.

Elizabethan Windows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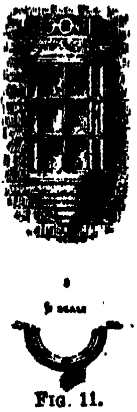

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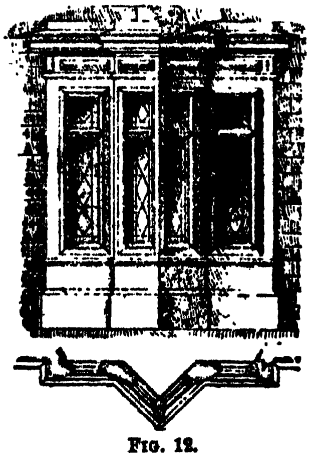


FIG. 12.

THE DOMESTIC HOUSE PLANNER (*see Text*).

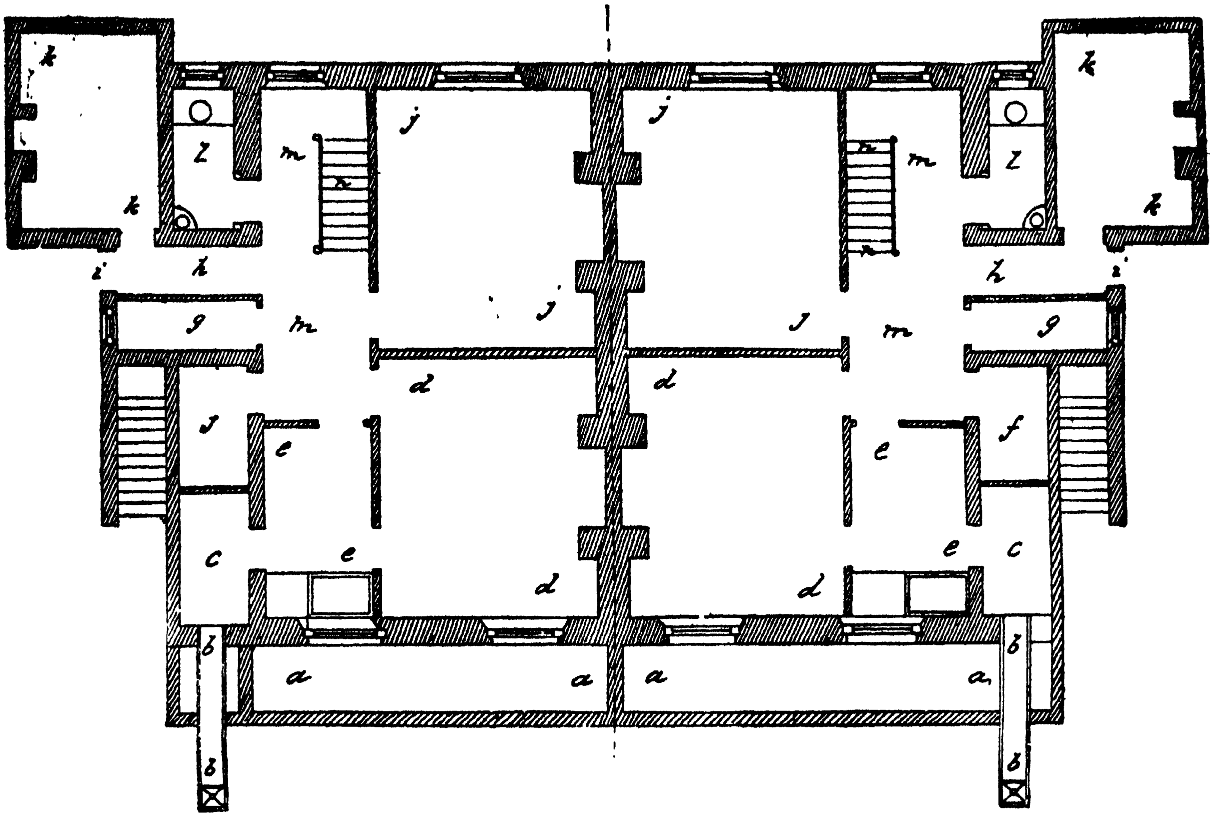


FIG. 1.—CELLAR PLAN OF HOUSE IN FIG. 2 (ELEVATION), PLATE CLXXIX.

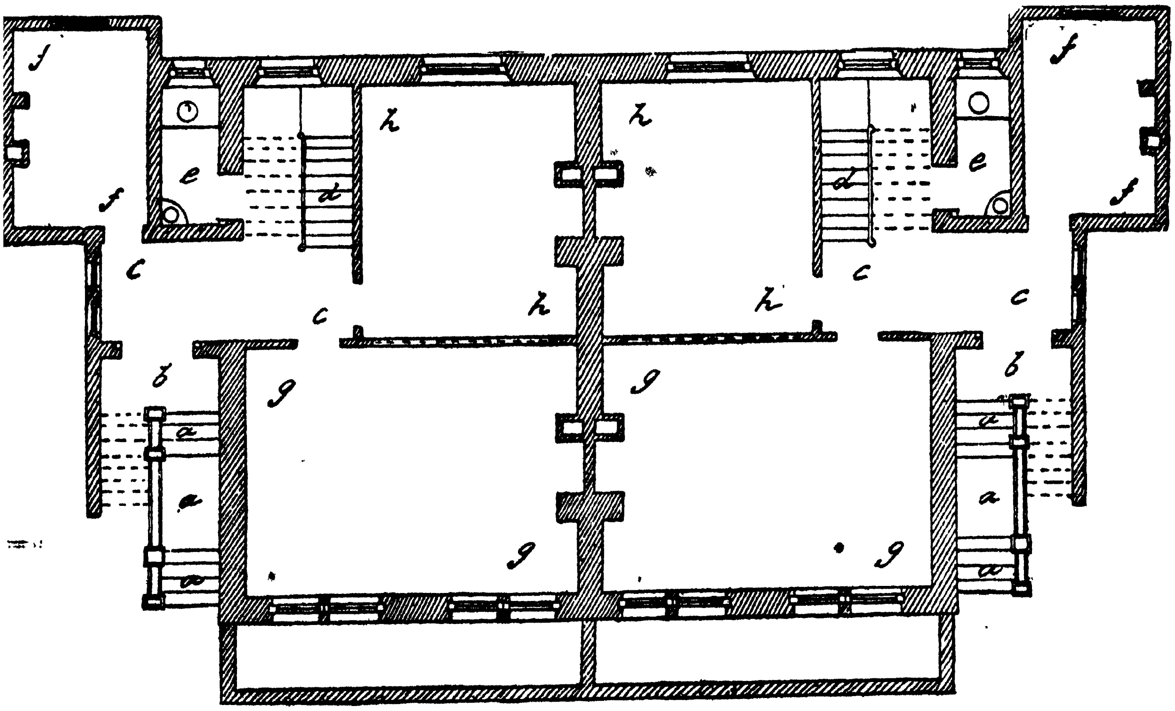
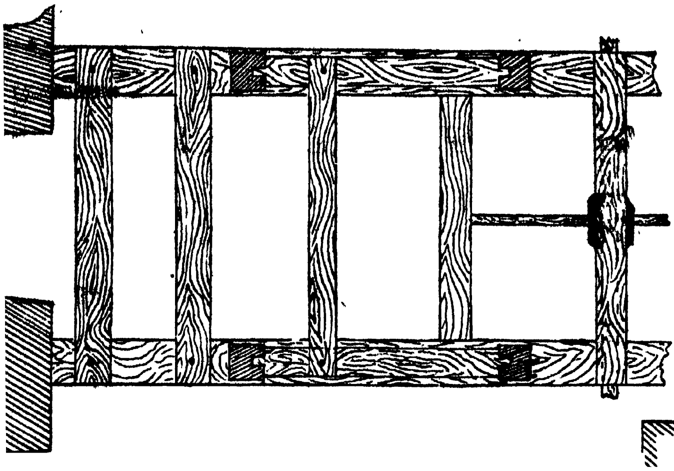


FIG. 2.—GROUND PLAN.

THE CARPENTER (see Text).



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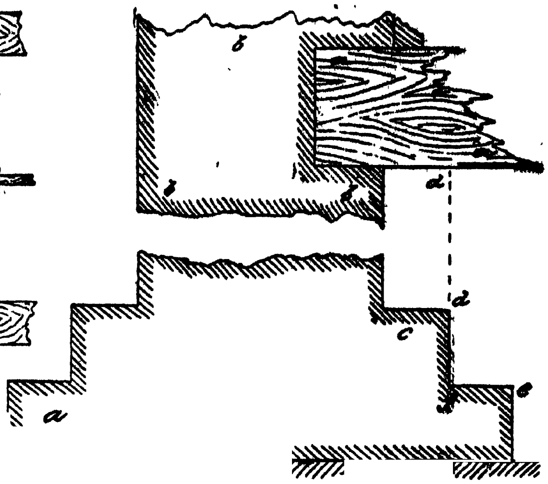

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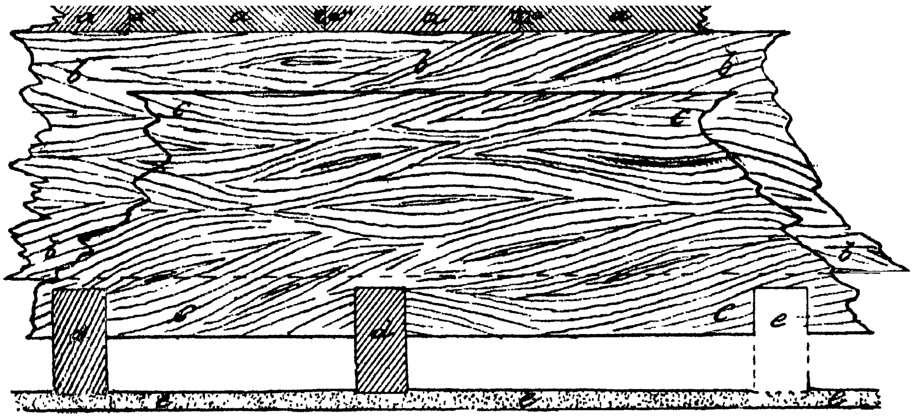

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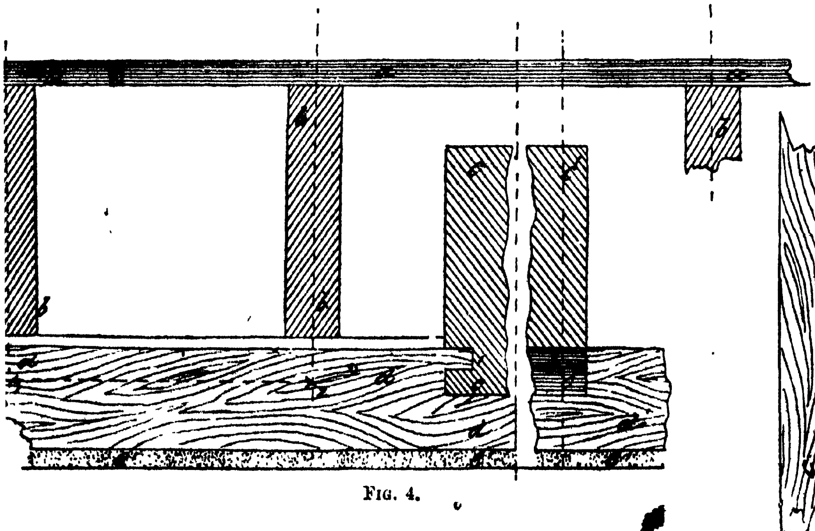

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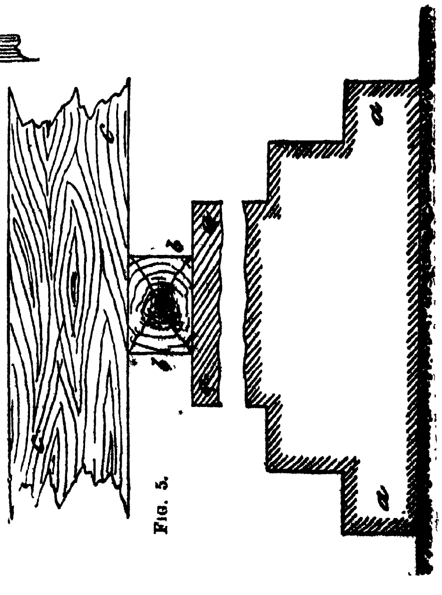
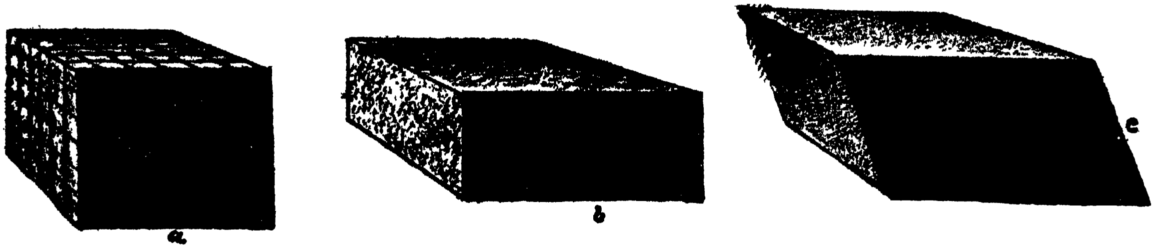


FIG. 5.

THE GEOMETRICAL DRAUGHTSMAN.



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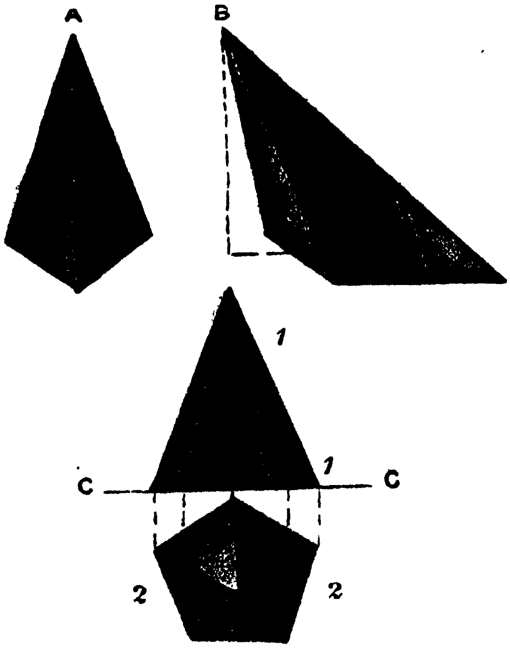


FIG. 2.

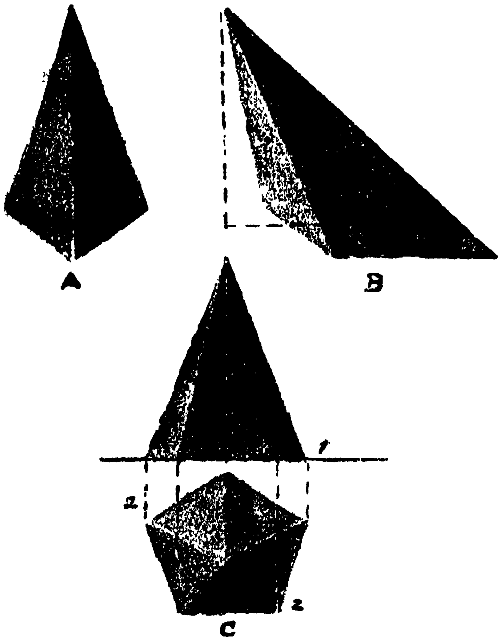


FIG. 3.

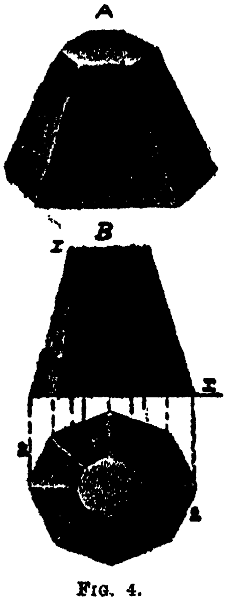


FIG. 4.

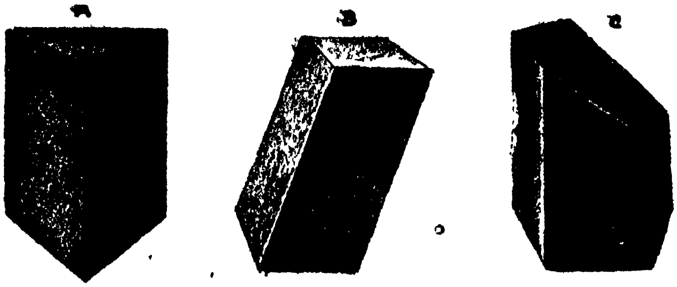
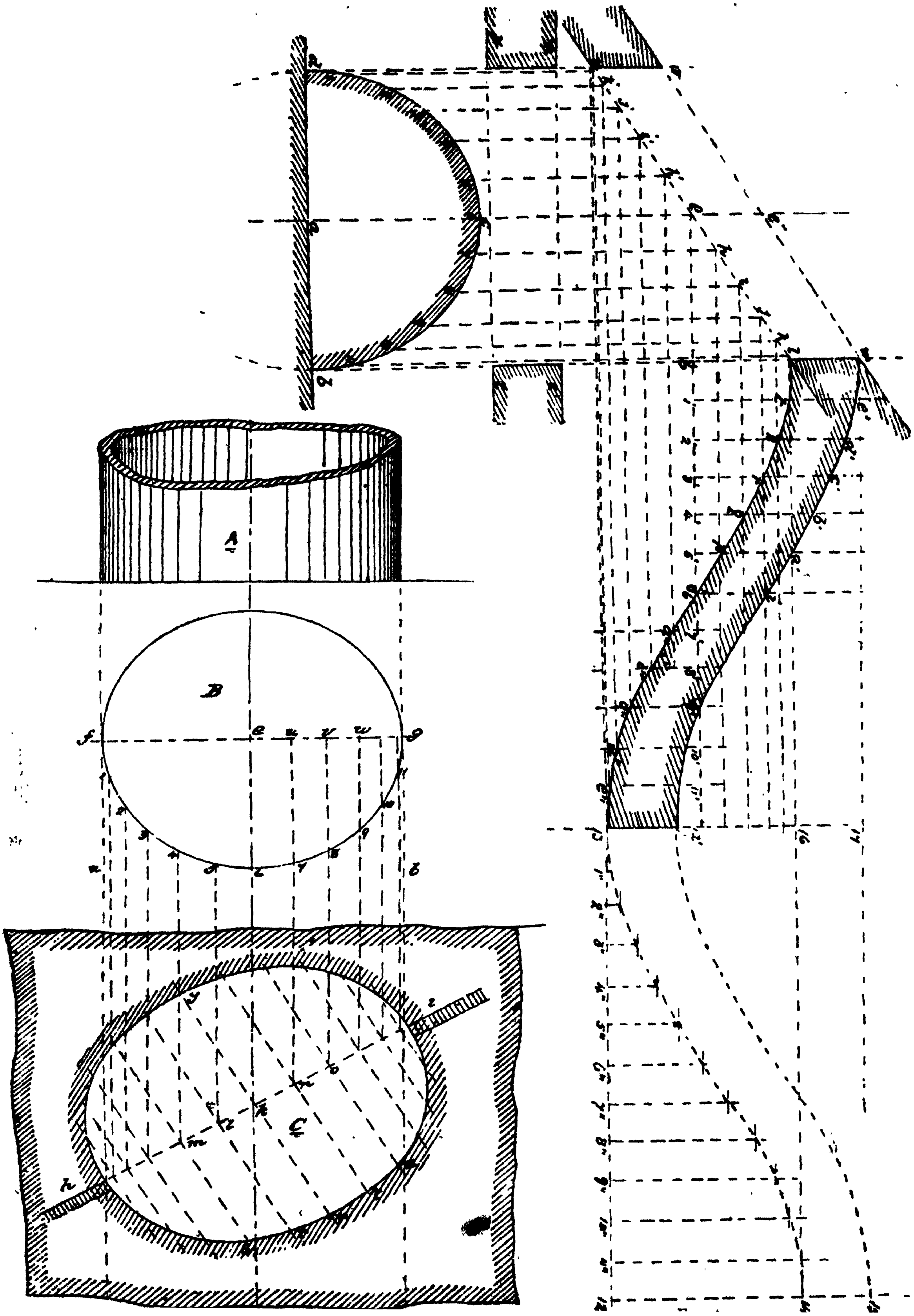


FIG. 5.


A
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THE TECHNICAL STUDENT'S INTRODUCTION TO THE GENERAL PRINCIPLES OF MECHANICS.

LAWS AFFECTING NATURAL PHENOMENA—MATTER AND MOTION.

CHAPTER XXVI.

At the conclusion of last chapter we stated that the finish of the cap or upper courses of a chimney stalk was generally considered as a matter of no moment. Mr. Carmichael has, however, pointed out the fallacy of this, and showed how a great deal of the efficiency and importance of a factory or large chimney stalk depends upon the finishing of the top. Thus, by finishing the top by an arrangement shown in elevation at *v* and *w*, plan at *x x* in fig. 23, several advantages were obtained and defects cured. The deflecting plates, as *w*, of brickwork are arranged in cross fashion or diagonally, as shown at plan in *x x*, meeting in centre and leaving opening for the smoke.

Recoil—Blows—Striking.

We give these illustrations to show that the student by a little thought to his study can, by very simple means and cheaply devised and constructed appliances, illustrate various physical laws in so forcible a manner that they will be impressed upon his mind with the force of concrete facts rather than, as in the case of a mere reading of them, by their abstract ideas. The laws explained in these paragraphs the student will find exemplified in many of his operations in the workshop, if he will but devote some thought to what he is engaged in. In striking or driving up bodies he may, if not careful in deciding the directions of the blows, have a painful exemplication of the law that the angle of incidence is equal to the angle of reflection, by sustaining a shock or a blow upon which he did not reckon. And he may have driving up to do in such positions that he must perforce illustrate this law, if the work is to be done in the best and safest way. The action of the law is in fact illustrated or enforced by the common saying "*a well-directed blow.*" How this is so the student will see by thinking over it.

Viewing the effect of a recoil in striking and struck bodies—impacting and impacted—due to the law of repulsion as caused by the action of springs between the bodies, which are first compressed or changed from or expanded into the original form and positions, we have some very curious and to many unexpected results to which the name of mechanical may be given. We have seen that in the recoil of a body from the surface of another body, and both of them elastic, in which the direction of the force is in a straight line at right angles or nearly so to the struck or impacted surface, or in the same direction, theoretically the force of the recoil is equal to that of the projecting force with which the body was driven up against the surface, when the bodies are equal in mass. But we have some curious and what appear to be paradoxical effects produced by the recoil of bodies between the size, mass or weight of which there is a decided difference—that is, when a small body strikes a large body. Beginners in mechanical work who are not careful may find, for example, that the blow unexpectedly received from the recoil or rebound of a small hammer from the face of an anvil which is struck by it seems to them to be the measure of a much more powerful blow, or to be a "stronger," than what appears to be reasonably or precisely due to what they felt to be the strength of the original blow. And it is so in reality, for the force of the blow given is greater than that of the blow which caused it. So decided is this action in some cases, and so curiously exemplified, that not a few who indulge in the dreams like those of seekers after a perpetual motion, or in other words, the making of a power which will at once create and maintain its own force, draw from them as conclusion that this wonderful power is within the reach of the mechanic. For here apparently, in the case above quoted, there is a force—the extra strength or force of the recoil—which is created, for it did not exist in the original blow. But the curious and to the popular mind unexpected effect is easily accounted for in the case of small bodies striking or impacting against large bodies: thus, a ball striking against a much larger ball, and recoiling from it, gives to the larger ball a blow or momentum greater than that which it possesses itself, and this equal to the force with which it (the small ball) rebounds; for, still keeping in view the motion of a spring between the two bodies, this spring acts equally in both directions.

Practical Points Enumerated.—The Principle of Action and Reaction.

The points involved in the principle of "action and reaction," explained in the preceding paragraphs, must be carefully considered by the mechanic in designing machines. Those have to be considered from two points of view: first as combinations of parts which under statical pressures are considered to be at rest, so that there should be what practically results as a balancing of parts, in which the weight and the breaking strain or pressure which it exerts in one direction is counterpoised, so to say, by a weight exerting an equal pressure or strain in another direction. But it is when the machine is considered from the other point of view—as a combination of parts in motion—that the importance of attending to the principle of action and reaction is seen. The arrangement of the parts of a machine which normally are at rest comes under the head of what may be called a "statical" or standing balance of the weights and pressures or strains of parts. The arrangement of the parts which are in motion come under the head of what may be called a "dynamical" balance, or balance of moving or removing parts. It is, however, to be noted that the two balances are involved in the consideration of the design of the moving parts of machines. Thus, a shaft which has a motion of revolution the balancing of the reactions of which is in its relation to other moving parts comes under the head of a dynamical or a running balance; but as a single element in the machine it has to be considered in the relation which it bears to the resultant of the weight or pressures under the influence of which it acts or is loaded, as well as of other weights or pressures acting upon it. In this case a statical or standing balance is effected by taking care that the resultant of the weight or weights should pass through the axis of the shaft. For example, this is effected, in the case of the main shaft of a steam engine, by adding counterpoise or balance weights in such a way that the pressure or weight strain thrown upon the shaft by the crank or cranks and the eccentric or eccentrics is counterbalanced. In such a case, half of the weight of the connecting rod has to be taken as a load or strain acting on the crank pin to which it is jointed. In beam engines the weight of the beam—or beams, as in side lever marine engines—of the piston, piston rod, parallel motion, etc., should all be so arranged that they may be balanced at, or that the resultant of all their pressures, loads or strains should pass through the axis of the main shaft or centre. But the points involved in the principle of action and reaction are most strikingly exemplified in relation to the moving parts of a machine. In those, especially where they "run" at a great speed, it is obvious that any parts improperly or carelessly balanced will give rise to undue strains, shocks and jars, which will prove very prejudicial to the life of the machine. All motions in machines are resolvable into motion in two directions only, one of which is motion in rectilineal lines, or reciprocating, oscillating or vibrating parts, and the other motion in a circular direction or motion of revolution round a centre. Generally the reactions of reciprocatory parts, such as those of beam and side lever engines, are balanced by the same provisions which are made to insure what we have seen to be the standing balance of moving parts. Much depends upon the character of the motion of the machine: thus in direct-action steam engines the reactions of the piston and its connected parts cannot be accurately balanced without inducing unbalanced centrifugal forces. This will be evident by considering the main shaft, through the axis of which the resultant pressure of the parts passes, as balanced by counterpoises fixed at the side of the shaft opposite to the cranks, so as to balance the weight of the parts concentrated at the crank pins; for the centrifugal force of those counterpoises balances the reactions only when the force acts in the direction of the stroke of the engine, but not when it acts transversely to this, in which case a centrifugal force guaranteed by the counterpoises is itself unbalanced. In the case of parts in motion having a motion of revolution, or turning round a given centre or shaft, what we have called the statical balance of parts must be secured by having the weight of the revolving part equally disposed on all sides of the centre or axis, so that the weights or strains communicated to that axis shall always be equal and opposite. Thus, if we have a weight acting one side of the axis, we then make a balance of the parts, and thus have the centrifugal forces generated by the two weights equal and opposite, and thus have a good running or turning balance. In connection with what is called centrifugal couples, it is to be noticed in the present connection that to secure a coefficient running balance of parts of machines having a motion of revolution round a central shaft or axis, the counterpoises or balanced parts or weights should be placed on a shaft, so that centrifugal couples may not be created; or if by the necessities of combination of the parts of the machine those couples are created, then they should be so arranged as to balance one another.

Motion in Straight Lines.

Much as has been said on the subject of motion, and numerous as have been the practical applications of the phenomena which it exhibits, we have by no means exhausted all that can be said of it. After what has been stated as to the phenomena of accelerated and retarded motion arising from or caused by the two great and the only two forces existing in nature,—attraction and repulsion,—the youthful mechanical student may have, at first, a great difficulty to perceive that all moving bodies have a tendency to keep in uniform or equal motion—that is, not quick at one time and slow at another. To perceive this great truth clearly will require a little "thinking of it over," and if he give this he will see that the natural tendency of all motion is to be in this uniform or equal condition. If it were not so, if this law did not exist, the reader will perceive that there could be no calculations made as to anything connected with motion, which could be relied upon; for, if a body in motion had at one time a slow and at another a quick velocity, and this change was of necessity, under such circumstances it would be quite uncertain as to the times or periods when the change would develop itself,—it would be, so far as man is concerned, an unknown qu[illegible]tity: it might be any time, for the change might be taking place from quick to slow motion at the very time he was calculating upon it as being of a certain velocity. There would, indeed, be nothing certain in any of the natural phenomena, no matter whether concerned with the sources of motion, or with the planetary bodies, the motion of which gives us the only idea of "time" we practically have. It is just because motion is naturally uniform that we can calculate as to time, and therefrom calculate as to all motions.

Uniformity of Motion.

In saying that motion is uniform, or naturally uniform, it does not in the slightest contradict what has in the preceding paragraphs been said as to the different varieties of motion, which is, as we have seen, caused or brought into existence by what we call a "force,"—and so long as this force is in its operation left to act, that is, is not influenced by another force, the motion which it gives to the body remains unchanged. The motion thus influenced, motion not subjected to any second force, is therefore uniform, Uniform motion may, however, be relative—that is, in relation to or in comparison with the motion of some other body, whatever that relation is, always uniform—that is, it is maintained throughout. But this only so long as no disturbing cause comes into existence; and, if it does, we then find that all changes from the uniformity are proceeding in proportion to the extent and influence of the disturbing cause. This is but another way of saying that uniformity of motion can only be done away with by introducing the action of some force other than that which originally caused the motion; or that each variety of motion has a certain velocity, which will be infinitely maintained, but if it is found to possess at a certain point a greater velocity, it shows that a new force must have come into existence or been brought to bear upon the body, otherwise the change in velocity could not have come about. And the converse, when the original velocity is made to be slower, holds equally true. This following well-known law we have previously explained, showing that a body cannot be brought to rest which is in motion without a fresh or new force or cause, any more than a body at rest can be set in motion without a force or cause of some kind. Hence, also, it follows that the natural tendency of all moving bodies is to move equally.

Changing the Direction of Motion.

From what is said above, it follows that the natural tendency of bodies in motion is to move in straight lines. This must be so, for as new forces must be brought into play to produce new velocities, and changes in the natural uniformity, so new forces must be brought into action in order to change the direction of a moving body, which original direction must be straight, or in a right line—that is, in a direction the same as the acting force, for all single forces act in straight lines. The clearest conception we have of a straight line is the course taken by a stone falling from a height, or from the top of and clear by some distance from the body or masonry of a tower. Or, if the motion be reversed, and we project the stone upwards by some force which acts in a direction precisely at right angles to the surface of the earth, we have a clear conception of what a straight line is. We see this straight line more obviously and easily in the case of a jet of water thrown from a vertically-placed tube. But an infinite variety of phenomena in nature exists around us to show that all motion is naturally straight when left free from all disturbing influences or forces. A ball projected from a cannon does not go straight and in the course which it originally had, simply because the force of gravitation or the attraction of the earth bends or deflects it from that straight course. But the student must be careful to note that this curved or bent line which the ball takes as it approaches the earth does not affect the truth of the statement that the motion is naturally in or has an invariable tendency to go in a straight line. For, while this bend or curve towards the surface of the earth is caused by a force other than that of the projecting force, which is the repulsive force of the explosion of the gunpowder—namely, the force of gravitation—the direction of motion of the ball, or, to use the technical term, the flight or path of the projectile, is otherwise absolutely and perfectly straight (as from point *a* to *b*, fig. 24), in the sense that it does not deviate either to the right hand or to the left, as from *a* to *c* or to *d*. On this tendency of all bodies to move in straight lines depends the whole practice of what may be called the mechanics or science of projectiles—that is, using the better term to denote all classes of "ordnance," military artillery or ordinary firearms. If this principle or law or tendency did not exist, no rifleman or artilleryman could ever calculate on hitting the mark he aimed at. If the aim be absolutely true, he knows that, making certain allowances for winds or breezes, the ball will hit or strike the point aimed at, or to use the popular phrase, which in this instance at least is also scientifically correct, the ball "will go straight to the mark." But the youthful reader may yet fail to see how the force of gravitation, as in the instance of the ball *a* or projectile (fig. 23), which

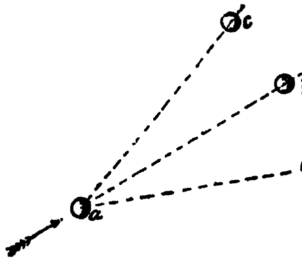

Fig. 24.

bends away from its straight course in the line of its parallelism to the surface of the earth, as in the line *b c*, is to be overcome, for this force is always acting on bodies moving or free in the air; *a d* is this parallelism. Supposing the height of the "bull's-eye," *d*, of the target to be at the same height from the ground as the height *b a*, the eye of the rifleman, or the line of centre of the cannon or "gun," all that is necessary is to have such a force of projection—that is, such a charge of gunpowder—that the ball will at least be projected as far as the point *d* before the force of gravitation begins to act. Practically a much larger allowance than this is given, or a wider margin of projectile force to the ball. In other words, and in more accurate terms, the explosive force of the gunpowder must be such that the weight of the ball will be prevented from acting so as to cause it to drop or have a tendency to drop, until at least the point *d* be reached. It may go in the same line as to the point *e*, after which the projecting force gradually weakening, the ball reaches the ground say at the point *f*, it taking a curved course, as already explained. The youthful reader must note that the parallelism of the line of path of projection *a f* to the earth's surface *b c* is not absolutely necessary to be mentioned, and is in practice being perpetually altered: for awhile the height of the target or bull's-eye *d*, as in rifle practice, remains the same; the height of the eye of the rifleman at *a* is ever varying. So that while one, a tall rifleman, has to shoot down to the target, another, a short man, has to shoot up to it,—as in field sports a man in killing a rabbit or a hare shoots in the line *a g*, and in shooting a pheasant or a grouse in its flight he has to shoot up as in the line *a h*. But in all the cases the force of projection given to the ball must be such that it will carry out at least as far as the point *e*, *g*, or *h*, before the *weight* of the ball begins to act, causing it to drop, or before in other words the force of the attraction of gravitation comes into play. So far as the principle is here concerned, while it is true that the tendency of the motion of the ball is in the absolutely straight line, as *a b*, *a c*, or *a d* (fig. 22) *ante*, it is, however, to be noted by the youthful reader who is well acquainted with the fact that there is "bad shooting" and "good shooting," that there may be—in practice to a large extent there are—influences at work modifying what is called the "accuracy of the arm," which means the correctness of the results. We do not here refer to what is known as a "good eye" as a powerful element in securing the success of a marksman: we refer to modifying causes which are mechanical. Every player at "bowls" knows what is meant by the "bias of the ball," which gives it a tendency, even under skilful playing, to deviate from the straight line in which it is first projected from the hand of the bowler to a curved line such as that which the skill of the player shows to be necessary in order to place his ball in. Now, this deviation has its origin in two directions: first in the "bias" or shape of the ball, which is a certain deviation from the absolutely correct spheroid form; and secondly from the controlling force, so to call it, of the friction between the surface of his ball and the grass of the bowling green. How this modifying the straight or natural line of motion of the ball comes about, we shall see in a succeeding paragraph, in taking up curved lines of motion. But modifying influences in the practice of projectiles of mechanical character naturally alter its results. And just as we find that an arrow when shot or projected from a cross-bow with neither barb nor head will have a very unsteady, or as it is termed a wabbling course through the air, but by giving it the heavy barb at the one end or point, and the double feather head, we make it fly steadily and straight through the air,—so we find that by modifying the ball and its motion through the air we give it a straightness or directness of motion not otherwise attainable. This constitutes the art or science of "rifling" of ordnance. A cannon-ball not absolutely or truly a spheroid has a "bias" or tendency to deviate from the straight as much as the irregular sphere or ball of the bowler,—this acting in relation to the air just as the ball acts in relation to the grass-covered surface. By modifying the surface of the ball, giving it as it were a further recoil of the arrow by projecting surfaces, and by modifying its motion so that while it has a progressive motion due to an explosive or repulsive force of the gunpowder, it has also a motion round its own axis or diameter line, we overcome the tendency modifying the straight line of its course, and force it, so to say, to keep to this. And this rotation of the ball round its own axis, or the "spinning" of the ball as it is termed, is caused by having not a smooth bore or internal periphery to the cannon, but a grooved or channelled surface, this forming a part of a spiral or vertical course. Hence also the shape of the ball may be and is so altered that, assuming a form quite distinct from a sphere, it is no longer entitled to the old name of ball, but assumes the modern name of a "projectile."

Illustration Continued of Tendency of Bodies to Move in Straight Lines under the Influence of a Force.

An ignorance or overlooking of this, the natural motion or tendency of moving bodies to go in a straight line, has given rise to grave errors in mechanical or engineering construction. We illustra[illegible] a few points in connection with fig. 24.

THE IRON MAKER:

THE DETAILS OF HIS WORK AND THE PRINCIPLES OF ITS PROCESSES.

CHAPTER X.

Further Action of the Spongy Iron in the Blast Furnace.—Carbon.

At the end of the last chapter we referred to the action of carbon on the particles of spongy iron, and gave a note or two in connection with it. In continuation of the subject we have to state that by this action Sir I. L. Bell believes that the ore, to use his own words, "during its reduction becomes impregnated with a large quantity of finely divided carbon," which he considers to be "an agent of much importance in the operation of the blast furnace." The capacity of the oxide of iron to take up the carbon thus provided is very great: one authority, indeed, states that, under such circumstances as Sir I. L. Bell has shown to exist in the blast furnace, a mass of oxide of iron will take up as much as four times its own weight of carbon. In practice, however, the resulting alloy of carbon and iron, or of iron and carbon, contains a very much less proportion or percentage of carbon, this varying from 2 up to nearly 5 per cent.

Different Zones of the Blast Furnace.—"Full Red Heat."—"Bright Red Heat."—"White Heat."—The Crucible of the Furnace.

The absorption or taking up or amalgamation with the various constituents we have named by the mass of spongy iron present at the zone of the blast furnace which we have still under consideration, tends to increase the fusibility of or the ease with which the iron can be reduced or smelted by the action of the high temperature of the fuel combustion. And it is when the absorbing or combining process is completed—in the zones marked in the diagram, fig. 1, Plate CLXVII., which are known as the zones of "full red heat" and "bright red heat," but which we have comprised under one zone, to which we have given the name of that of "absorption"—that the process of complete fusion commences, it being completed at the zone termed the "zone of fusion" (see same figure). The blast furnace at this point becomes much reduced in diameter, and is indicated by the angular lines *d p*, *r q*, fig. 1, Plate CLXVII. This narrowing or decreasing of the area of the furnace between those lines in which the zone of fusion is comprised is rendered necessary by the decreasing bulk of the iron now in a state of fusion; and it serves also to intensify the temperature which at the lowest point, or that at which the "crucible"—as it is called—of the furnace is situated, at the point where the furnace is at its narrowest, is at the "white-heat" zone. When the smelted iron in its downward course passes through this white-heat zone, the fusion or reduction is complete. The mass of melted metal thus assumes the lowest position, the "slag" or glass-like silicates being lighter or of less gravity, floating, so to say, on the top of the melted metal.

Completion of the Process of Reduction of the Ore in the Blast Furnace.—Final Products.—Pig- or Cast-Iron.—Slag.

The metal is now ready to be withdrawn from the furnace, which is done by opening the tap hole; and after it is withdrawn the melted slag is next taken out, the two products being thus quite distinct and separate. The action of the intense heat which reigns in this the lowest or crucible part of the furnace—which is at the region where the heat-producing blast from the blowing engine is supplied—would be to burn or otherwise destroy or deterioriate the quality of the iron if it were exposed to it. The molten metal is, however, protected, and by the natural relative disposition of the slag, which we have seen above floats on and lies upon the surface of the molten metal, it arrives at a certain point in the height of the crucible or the hottest portion of the furnace beyond which the depth of the "bath" or mass of molten metal is not allowed to increase. When this point is reached the furnace is "tapped," and the metal withdrawn and run into a channel or mould formed in the sand which constitutes the floor—so to say—of the space in front of the blast furnace devoted to the running out of the metal. Those main channels or moulds are termed, in the strange technicalities of the iron districts, "sewers." Branching off from those main channels are minor ones, or moulds, into which the molten metal runs, and these branch or subsidiary moulds or channels are termed "pigs." Hence the term by which the long bars of cast iron, so familiar to every one, are known to the trade, of "pig iron," or simply "pigs." The length of these "pigs" is about four feet, and the cross section shows a rounded top with a flat base, the breadth of which is about three to four and a half inches, and the thickness at the deepest part of the curve some three to three and a half inches or thereabouts.

"Trade" Qualities of the Iron produced by the Reduction of the Ores in the Blast Furnace.

From what has been given in preceding paragraphs on the qualities and constituents of ores, and on the action of the blast furnace on them, and the elements of the "charge" used therein, the reader will readily perceive that the quality of the iron produced will vary very much in physical structure and in the elements of constructive strength. The trade decides the qualities of cast or pig iron by classifying them in a general way under two great divisions, the colour of which gives the class. These two classes are known as the "grey" and "white," the descending order here denoting the position of their constructive value, the poorer iron coming under the white, the better under the grey. There is, however, a third class, which is intermediate between the grey and the white; to this the name of "mottled" iron is given. The "trade" distinguishes the different varieties of cast-iron by numbers. They range from "No. 1" to "No. 6." The "No. 1" shows a fracture largely crystalline, with a dark grey colour. This, in the work of the foundry, is much used for articles in which great strength is not required so much as a capability to give sharp and well-defined outlines or edges. This characteristic depends upon the fusibility of the iron, or the comparative ease with which it can be melted, and its fluidity, which admits of its penetrating, so to say, all the finer intricacies of the mould. This "No. 1" is also used in foundry practice to mix with the other varieties or higher numbers, as "No. 2" and "No. 3," which are less fusible than "No. 1." "Nos. 2 and 3" have the grain proportionally smaller than that of "No. 1," with a colour gradually getting lighter. Those irons—"No. 1," "No. 2," and "No. 3"—constitute what in a general way are called "foundry irons," or what may be strictly called cast-irons for moulding purposes. The higher numbers, as "No. 4," "No. 5," and "No. 6," are known as "forge irons," and are classed generally under the "white" variety. We have ended the description of "No. 3" by stating that its grain is finer and its colour lighter than those qualities in "No. 1"; and it is at this point, in ascending to the higher numbers, that the variety known as "mottled" appears. This is distinguished from "No. 3" by having patches of a lighter colour, and when these are very pronounced or decided then the name "mottled" is applied. As these light-coloured "clouds" or patches increase, and the dark-grey colour disappears, the metal comes under the class of white, of which "No. 4" is the first and "No. 5" and "No. 6" are the two highest—at which point the lowest or poorest grade of iron in constructive value is reached. Those white irons are hard and brittle, and are difficult to melt or fuse. The "No. 4" is chiefly used to mix the lower and softer varieties, as Nos. 1, 2, and 3, imparting to them some of its characteristics.

We have seen in the last chapter that the cast iron of commerce is not by any means a pure iron, being in the best of qualities well, and in the worst very far indeed, removed from this. The iron of commerce is, in fact, an alloy of varying character according to the constituents present in it. We have seen how these became present in the iron, and how they are absorbed or amalgamated from the debasing constituents present in the materials or charge supplied to the blast furnaces. Iron, strictly speaking, is an alloy of carbon and pure or metallic iron; the other constituents, such as sulphur, phosphorus, silicon, and manganese, being debasing or deteriorating elements. Although the two last named are less debasing than the two first named, in some respects manganese is a useful, not a debasing constituent. And it is on the proportion in which carbon is present in the iron alloy which forms the cast iron of commerce, that the existence or formation of the various "Nos." depends. The condition in which carbon exists in the cast iron of commerce is a disputed point amongst metallurgists. One class maintain that it is present in iron in two forms or conditions—one of them being chemically combined with the metallic or pure iron, the other being mechanically combined or mixed with it. The chemical combination is called a "carbide of iron," —the mechanical combination is by this class of metallurgists known by the name of "graphite." This view of the alloy of pure metallic iron and carbon which constitutes the cast iron of commerce is that generally held by those connected with the trade. It is right, however, to state that there are some who maintain that the carbon of cast iron is already present, chemically combined; but taking the generally held opinion, the difference in the qualities of the "Nos." of cast iron arises from the different amounts or per-centages of graphite which they contain. It is to the presence of graphite in comparatively high proportion that the fusibility and fluidity of the "No. 1" variety, and to the absence or comparative absence of it in the higher "Nos.," that their hardness, brittleness, and difficulty to be fused or melted, is due.

Practical Management of the Blast Furnace.

When a furnace, newly erected, is about to be started, the first precaution that should be taken is to see that it is completely dry: the smallest amount of moisture will afterwards prove injurious, and any trouble or expense taken in the first instance to insure this particular will be fully repaid. The fire in the furnace should be small at first, and increased or enlarged by degrees in such a manner that the draught created be strong enough to dry the place thoroughly, but not so intense that actual damage is done in the way of cracks, etc. The current is usually easily regulated by admitting air at the front or forepart, and covering both filling places and tunnel head. The entire furnace and supporting masonry having now been ascertained to be free from damp, the fuel may be carefully and gradually added. In large furnaces, such as are commonly employed in the Cleveland district, the precaution of dryness is specially important.

THE BUILDING AND THE MACHINE DRAUGHTSMAN.

CHAPTER XXI.

How to Project Building Plans in Perspective.

In continuation of this subject, commenced at end of last chapter, we have to remark that it is said of the late Mr. Edmund Street, the well-known architect of the Metropolitan Law Courts, that he always designed in perspective. Whether true or not, the system of doing so is an excellent one, particularly in the case of buildings portions of which are recessed from the general line of frontage; if the elevations of such a building are prepared only in the ordinary manner, they may, although thoroughly satisfactory on the drawing, be exceedingly disappointing when erected. An example showing how this may be the case will be found below. Perspectives are of course not limited to the exteriors of buildings: many portions of the interiors should also be illustrated. Thus, if designs are being prepared for a large villa, internal perspectives should be drawn of the staircase, hall, billiard-room, dining-room, and conservatory; if of a church, interior views of the nave looking west and of the chancel looking east are desirable. When a large number of buildings are grouped together, as in the case of a workhouse or lunatic asylum, or if a large building is surrounded by a number of subsidiary buildings and inclosures, as in the case of an extensive farmstead, "bird's-eye views" should be prepared, showing the general grouping as seen from an imaginary point overlooking the whole site, or as they would actually appear if seen from a tower or hill. In this paper and the accompanying illustrations we propose to give a few necessarily simple but practical examples of what may be called "applied perspective," as a general guide for the young architect and student. The process or system of working out the perspective will be explained step by step, so that every portion may be thoroughly understood; the reader is advised to make sure that he comprehends each statement before proceeding to the next, to avoid becoming confused and discouraged. Examples of exterior perspectives will be given.

The seven technical terms stated below must necessarily be used in the course of the paper, and a short explanation is appended to each; it should be perhaps first stated that a perspective is the representation of a building, or of any object, as it actually appears to the eye of an individual looking at it.

The terms will be easily understood if the reader imagines himself placed in front of any large isolated building, say a warehouse, in such a position as to be able to observe two frontages simultaneously.

1. *The point of sight* is the point from which the warehouse is seen—that is, the eye of the "observer."

2. *The station point* is the spot on which the "observer" stands; on the drawing it is a point vertically below the point of sight.

3. *The picture plane* is an imaginary plane, such as a sheet of glass, paper, or canvas, placed between the observer and the warehouse, on which the view as seen is supposed to be drawn.

4. *The horizontal line* is an imaginary line drawn across the picture plane from right to left, level with the "point of sight" or eye of the "observer."

5. *The ground line* is an imaginary line drawn across the picture plane parallel to the horizontal line, as far below it as the station point is below the point of sight.

6. *A line of heights* is an imaginary line drawn on the picture plane, at right angles to the horizontal line and to the ground line, on which the various heights are marked off.

7. *The vanishing points* are points to which the horizontal lines of the elevations of the warehouse would converge if prolonged: if the elevations are attentively looked at it will be noticed that the lines of the cornices, string-courses, and plinth appear to incline towards each other. The tendency of long horizontal and parallel lines to converge when seen in perspective is strikingly apparent to any one looking down a long, straight street. These technical terms will be more thoroughly understood if the diagrams shown on Plate VIII. are carefully studied and re-drawn to a larger scale by the reader.

Let A B C D (fig. 1) be the plan of any detached building of which it is proposed to prepare a perspective: the first step is the selection of a "station point," or the position a spectator looking at the building when erected must occupy in order to see the view that is to be shown on the drawing. It must be evident that the building might be viewed from many positions, from each of which a different view would be obtained. It is the duty of the architect to select the best position. Thus, from the point E only the front could be seen; from the point F the front and the left-hand side or west elevation; and from the point G only the front and the right-hand side or east elevation. It need scarcely be pointed out that both the left and right-hand sides of the building cannot possibly appear on the same drawing; if views of both are required, two drawings must be prepared. From any of the three positions, E, F, G, the front of the building will be visible; the architect must therefore decide whether the left or the right-hand side is to be included in the view. Let us assume that the front and the right-hand side or east elevation, B C, C D, are selected to be shown in the perspective. The position of the station point, G, may of course be varied considerably within certain limits: it might be placed much nearer the corner of the building, C, or much farther away; or it might be placed more to the left, in which case more of the front would be seen and less of the side; or it might be moved farther to the right, when more of the side and less of the front would be visible. It is not usual to select a station point from which the two elevations would appear to be of equal length. From the point G more of the front, the more important and longer elevation, can be seen than of the side. The distance of the point G from the corner of the building will, of course, depend on the surroundings of the site. If it is situated in a narrow street, the distance will be limited by its width; if there is no limit of space, it can be placed anywhere. In the diagram the distance C G is made equal to the length of the diagonal A C. The reader must not assume that this is done in accordance with any rule; none can be given for his guidance, but in many ordinary cases the distance C G may be made equal to the lengths B C, C D, or to the diagonal A C. Presuming the point G is selected as "the station point"—that is, the position from which the building is to be viewed—then the eyes of an individual stationed there, and looking at the building, will represent the "point of sight"; and on the plan (fig. 1), both the "station point" and the "point of sight" are indicated by the letter G.

It must be evident that if an individual stands at the point G and looks in the direction of the building A B C D, the point B will be the extreme point visible on the left hand. Similarly the point D will be the extreme point visible on the right-hand side. Join the points B and D to G by the lines B G, D G, as shown in fig. 1. It has been found by experience that the most pleasing perspective is obtained, if the angle B G D is an angle of sixty degrees, by moving the point G nearer to or farther from the point C; the angle B C D can, of course, be altered to any extent.

The "picture plane" must be obtained next. Connect the point G with the nearest point of the plan C by the line C G, and draw any line H H at right angles to the line C G; then the line H H will be the "picture plane"—which, it has been stated above, is an imaginary sheet of glass, paper or canvas placed between the observer and the object looked at. It will be evident that the extent of the perspective, as it will appear on the "picture plane" H H, will be equal to the length J J, which are the points at which the lines B G, D G, cut the line H H. It is now necessary to determine what size the perspective is to be made—that is, its length from right to left. The only limit is the size of the sheet of paper on which the perspective is to be drawn. If the line H H is placed *nearer* to the point G, as shown by the line H′ H′, then the length of the perspective is reduced to the length of the line J′ J′; whilst, if the line H H is placed *farther* from the point G, as indicated by the line H″ H″, then the length of the perspective is increased to the length of the line J″ J″. It is evident that if a perspective were required several feet in length, it it would only be necessary to place the line H H farther from the point G, and to prolong the lines B G, D G. In practice it is usual to place the "picture plane"—that is, the line H H—at some point between C and G. If, therefore, a large perspective is required, the plan must be drawn to a larger scale.

For the elevations B C, C D, two vanishing points will be required. From the point G draw a line parallel to the line C D, in the direction of the line H H: the point of intersection, K^1, will be the vanishing point for the elevation C D; similarly from the point G draw a line parallel to the line B C: the point K^2, at which it intersects the line H H, will be the vanishing point for the elevation B C. The vanishing point K^1 must be used for every portion of the side elevation parallel to the line G K^1, whether it is recessed or whether it projects; similarly the vanishing point K^2 must be used for every portion of the front parallel to the line G K^2. Thus, the vanishing point K^2 would be used for the recessed portion of the front N N, for the front elevation of the chimney stalks L L, and for the projection R S in the side elevation; the vanishing point K^1 would be used for the elevation N O of the recessed portion of the front, and for the sides of the chimney stalks L L parallel to the line G K^1. If portions of the elevations should not be parallel to the lines G K^1, G K^2, additional vanishing points will be required. If the reader will refer to fig. 2, Plate VIII., he will find the plan of a building, A B C E F, in which a wing projects at an obtuse angle, and having a large bay in front. Let G be the station point and point of sight, and H H the picture plane: it must be evident, from what has been stated above, that four vanishing points will be required,—one for every portion of the building parallel to B C, another for every portion parallel to C D, a third for every portion parallel to D E, and a fourth for J K. From the point G, therefore, draw lines parallel to the lines B C, C D, D E, J K, and points where they intersect the line H H will be the respective vanishing points required.

The mode of obtaining the positions of "lines of heights" on the plan must now be explained. On the plan, fig. 1, Plate VIII., a height line will be required on which to measure all the heights on the elevation B C, which will not be available for any portion of the elevation either projecting beyond or recessed within the line B C; the recessed portion, N N, of the front will require a separate line of heights, and similarly the fronts of the chimneys L L will require their own lines of heights; if one is placed farther back from the line B C than the other, separate lines of heights will be required for each chimney.

THE GEOMETRICAL DRAUGHTSMAN.

HIS WORK IN THE CONSTRUCTION OF THE FIGURES AND PROBLEMS OF PLANE GEOMETRY, USEFUL IN TECHNICAL WORK.

CHAPTER XIV.

THE "rhombus" is the rhomboid which has its four sides equal without its angles being right angles, as the four sides *a b*, *b c*, *c d*, *d a*, fig. 6, Plate CXLIII. If we draw the two diagonals *a c* or *b d*, we divide or resolve the rhombus into four triangles, the apex of each of which is at *e*.

The rhombus is constructed or described in the same way as the rhomboid, fig. 5, Plate CXLIII. The rhombus is what is called the "lozenge" or "diagonal square," as shown in fig. 7, Plate CXLIII. This may be described or constructed as follows. Draw the line *a c* as a horizontal line, and at right angles to this the perpendicular line *b d*, intersecting each other in the central point. Set off on the first line *a c* from central point, and on each side of this point a length equal to the half of the longest diagonal, as *a c*. On the second line, *b d*, set off in the same manner from central point a length equal to the half of the small diagonal, and we thus obtain four points which, being joined, will form the diagonal square or lozenge required.

From the preceding problems in construction on quadrilaterals we conclude that the rectangles or parallelograms and rhomboids which have the same base and the same height have the same surface. In the square, the rectangle or parallelogram and the rhombus, the diagonals divide the quadrilateral into two equal parts. If we draw the two diagonals they will divide each other into two equal parts. Lastly, in the square and the rhomboid and in the lozenge the diagonals intersect each other perpendicularly (see fig. 8, Plate CXLIII.). The "trapezium," or "trapezoid," is a quadrilateral which has only two sides parallel to each other, as *a b*, *c d*, fig. 9, Plate CXLIII. The surface of the trapezium is equal to the product of the height, *e f*, measuring the distance of the parallel sides by the half-sum of these same sides *a b* and *c d*. The half-sum of the parallel sides will always be equal to a third parallel, *g h*, intermediate and at equal distance from the two parallels *a b* and *c d*.

"To construct any quadrilateral of which the four sides and one of its angles are known or given."—It is understood that the order in which these sides are arranged, and the place which the angle given occupies, is in accordance with a given rough sketch, such as is shown by the outline *a b c d*, to the left of fig. 10, Plate CXLIII. Make an angle, B A D, equal to the angle given, *b a d*; set off upon the sides of this angle lengths, A B and A D respectively, equal to *a b* and *a d*; then, from the points B and D as centres, with radii *b c* and *c d*, describe two arcs of circle intersecting at C. Join B C and C D: the quadrilateral A B C D is the quadrilateral wanted.

The two arcs of circle described from the points B and D intersect also at another point than the point C; but this other point is necessarily on the other side of the line B D, in such a way that there can be no uncertainty, for this second point would give place to a quadrilateral presenting a re-entering angle, whilst the one proposed is of the opposite character.

To construct a rhomboid knowing two sides (*a b*, *a c*, fig. 11, Plate CXLIII.) and the angle comprised between them (as *b a c*).—Make an angle B A C equal to the angle given; upon the sides of this angle set off lengths A B and A C, equal to the sides given *a b* and *a c*; from the points B and C, with *a c* and *a b* as radii, describe two arcs of circle which intersect at the point D: this point is the fourth point of the rhomboid required. As a particular exemplification of this problem, we may point out the construction of a rectangle, its two dimensions being given, and as a particular exemplification of the latter, the construction of a square, its side being known or given.

"To construct a trapezium, its four sides being given." —It is understood that the order of these sides is thus given: that is to say, that the sides A B and C D are to be parallel, as in the sketch in fig. 12, Plate CXLIII. Take upon the base A B a length A *m*, equal to *c d*. If we joined the point D to the point *m* (this is not done here, as upon the diagram only the lines absolutely necessary for the construction are drawn) the quadrilateral A C D *m* would be a rhomboid, and would have then D *m*=A C: all would be embraced in the triangle B *m* D. Hence the construction now to be given.

Make a triangle *b m d* having for sides the difference *m b* of the two bases and the sides of the trapezium, which are not parallel, as *a c*, *d b*. Upon the base *m b* of this prolonged triangle let us take a length, *b a*, equal to the base of the trapezium; from the points *a* and *d* as centres, with *a c* and the upper line *c d* as radii, describe arcs of circles which intersect at the point *c*. *a b c d* is the trapezium required to be constructed.

Problems connected with Polygonal Figures, or those having more than Four Sides.

Having in the preceding paragraphs given various constructions or problems connected with different classes of quadrilateral or four-sided figures, we now come to the consideration of those figures having more than four sides. Those figures, such as the pentagon, hexagon, etc., are by some geometricians considered those to which the term polygon—many-sided—if not correctly in the absolute sense—at least most appropriately applies. Certainly the term many-sided does not seem to apply very consistently to such a figure as a triangle, having only three sides, however it may be reasonably applicable to the square, having four sides.

The first polygon we have to notice is the "pentagon," which is a figure having five sides, as in fig. 1, Plate CCXV. Pentagons are classed as regular and irregular.

"To inscribe a regular pentagon in a circle."—Divide the radius *a c* into extreme and mean proportionals. The largest of the two divisions, *a b*, will be the radius of the arc, forming the tenth of the circumference; and, in joining the points of division, the regular inscribed pentagon will be constructed. On another method of inscribing the regular pentagon, we obtain the length of the line which divides the circumference into five equal parts, thus.

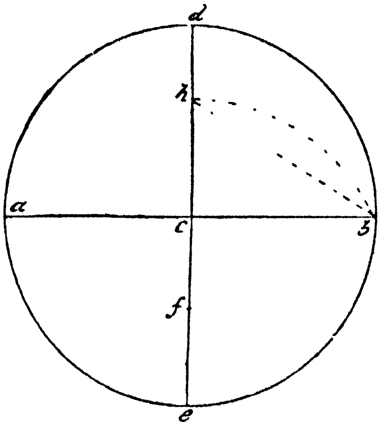

Fig. 73.

Draw two diameters, *a b*, *d c* (fig. 2, Plate CCXV.), which intersect in the point *c*; divide the radius *c e* into two equal parts at the point *f*. From this point as centre, and with radius equal to *f b*, describe the arc *b h*; the straight line *b h*, the chord of this arc, will be the side of the inscribed pentagon. The surface of the pentagon, like that of all the regular polygons, is equal to its perimeter multiplied by half of the radius (*d c*) of the inscribed circumference (fig. 1, Plate CCXV.). Each angle of the pentagon is equal to 108°.

The hexagon is a polygon of six sides. To construct the regular hexagon, the length of one of the sides of which we know, describe the circle, the radius of which, *a o* (fig. 2, Plate CCXV.), is equal to the given side; this radius, carried six times round the circumference of the circle, will divide it into six equal parts; in uniting the points of division, we obtain the regular hexagon. Each angle of the hexagon is equal to 120°. (See the papers under the title of "The Building and Machine Draughtsman" for a method of constructing hexagons very quickly by means of a set-square of 30° and 60°.)

The heptagon is a seven-sided polygon. To obtain the side of the regular heptagon, describe a circle, as in fig. 3, Plate CCXV. Having drawn the radius *a c*, describe from the point *a*, as centre, an arc having the same radius as that of the circle, and which will cut it at the points *b* and *d*; in joining these two points by a straight line, which will cut the radius *a c* at the point *e*, we have the distance *e d*, which will be—within the merest trifle—equal to the side of the regular inscribed heptagon. This line is then to be carried seven times round the circumference of the circle. Each angle of the regular heptagon is equal to 128·34°.

The octagon is an eight-sided polygon. To construct the regular octagon, describe a square, *a b c d* (fig. 74), and its diagonals, *a c*, *b d*, which divide each other into two equal parts in the point *e*. From each of the angles, as *a*, *b*, *c*, *d*, as centres, and with the half of the diagonal, *a c* or *d c*, as radius, describe four arcs, as *f i* or *l g*, which will cut each of the two adjacent sides of the square, as in the points *f* and *l*, and which will give eight points, as *f g*, *h i*, *j k*, *l m*, which will be the eight points of the angles of the regular octagon.

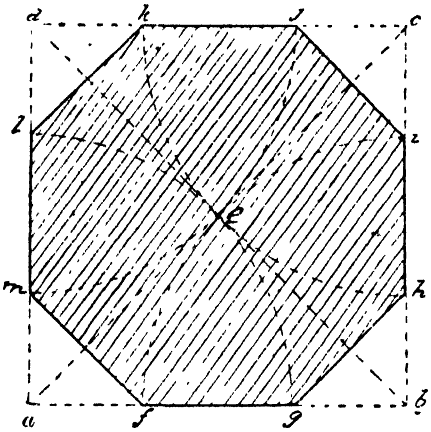

Fig. 74.

To inscribe a regular octagon in a given circle, as in fig. 4, Plate CCXV.—Draw the two diameters, *a b*, *c d*, perpendicular to each other; divide into two equal parts, as in the points *f*, *g*, *h*, *i*, *j*, each of the four quadrants measuring the four right angles formed by these diameters, and thus eight points of division are obtained, which are the eight points of the regular inscribed octagon. Each angle of the regular octagon is equal to 135°.

The nonagon is a nine-sided polygon. To inscribe a nonagon in a given circle, of which *a* (fig. 75) is the centre and *a b* the radius.

From the point *b* taken as centre, and with the radius *b a*, describe the arc *d a g*. Join the two points *d* and *c*, and from the point *e*, intersection of *a b* and of *d c*, as centre, and with the same radius *a b*, describe the arc *f g*, and from the point *f* as centre, with the same radius, the arc *e g*.

THE CALICO PRINTER.

THE CHEMISTRY AND TECHNICAL OPERATIONS OF HIS TRADE.

CHAPTER XVII.

Properties of Indigotin or Pure Indigo (continued).

INDIGOTIN (see end of preceding chapter), when carefully heated to 290°, rises in beautiful red-violet vapours, of a strong and characteristic odour, and these on condensing on a cold surface form fine small crystals of a deep-blue colour, of specific gravity 1·35.

(*b*) Solubility.

Indigotin is insoluble in water, alcohol, ether, fatty and essential oils, and in dilute acids and alkalies. Traces of indigo are dissolved by aniline, by creosote, and by phonic acid. Anhydrous acetic acid mixed with a small quantity of sulphuric acid dissolves finely powdered indigo, and the deep-blue solution which is obtained dyes wool by mere dipping and drying. The addition of water precipitates the dissolved indigo unaltered. This is the only case in which indigo can be dissolved without change and used for dyeing wool. Sulphuric acid, concentrated and warm, dissolves completely and readily, yielding a bright sky-blue solution known as

(*c*) Extract or sulphate of indigo, or soluble indigo, which is used in wool and silk dyeing, and is a beautiful sky-blue body, readily soluble in water, but insoluble in concentrated saline liquids. It is made by dissolving indigo in warm concentrated vitriol, and neutralising the excess of acid by the addition of alkali, whereby the sulphate of alkali is formed, which causes the sulphate of indigo to precipitate; it is then filtered, and the paste obtained sold as indigo extract. Sulphate of indigo readily dyes wool and silk by mere dipping and drying, but it cannot be fixed on cotton except imperfectly by means of albumen. Sulphate of indigo is decolorised or bleached by oxidising agents, as in the case of indigo blue.

(*d*) Action of oxidising agents on indigo.—Principle of indigo-discharge colours.

Oxidising agents—dilute nitric acid, free chromic acid, red prussiate of potash and caustic soda, free chlorine and many other substances—destroy the colour of indigo by converting it into *isatin*, a colourless body differing in its composition from indigo only in containing an additional atom of oxygen. This principle is made practical use of in printing, in producing a white or coloured pattern on indigo-blue dyed cloth—a subject which will be fully treated in its proper place in these papers. Stronger action—namely, by concentrated and hot nitric acid—converts indigo into indigotic or nitro-salicylic and picric acids, with elimination of carbonic acid or oxalic acid.

(*e*) Action of reducing agents on indigo.—Principle of indigo dyeing and printing.

By the action of nascent hydrogen (see "Tech. Dict.") in presence of caustic alkali, indigo is *reduced* or converted into a colourless body, called *White or Hydrogenised or Reduced Indigo*, which dissolves in excess of caustic alkali, and which is very readily brought back into indigo blue, by exposure to the air. Many reducing substances effect the conversion of indigo blue into indigo-white-ferrous sulphate, tin crystals or stannous chloride, realgar, glucose, gallic acid, alkaline metals, certain metals and non-metals in presence of alkali, as tin, aluminium, phosphorus, etc. Practical application of the reduction of indigo is made in indigo dyeing and printing, which will be treated in their proper place.

The presence of the various substances present in commercial indigo other than indigotin does not affect the above reactions, so that the properties of indigotin as we have stated them above, are the properties of good commercial indigo.

To make the subject of the properties of indigo clear we now name the four compounds with which we have to do in the practical uses of indigo, and some of their properties.

1. *Pure Indigo Blue, or Indigotin*, $C_{16}H_{10}N_2O_2$, a blue, volatilisable compound, insoluble in water, dilute alkalies and acids, alcohol, ether, etc.
2. *White, Reduced, or Hydrogenised Indigo*, $C_{16}H_{12}N_2O_2$, a colourless body soluble in caustic alkali, and converted into indigo blue by oxidation, by exposure to the air, etc.
3. *Isatin, or Indigotic Acid, or Indigo Discharge*, $C_{16}H_{12}N_2O_3$, a colourless body, soluble in water, acids and alkalies, etc., and not reconverted into indigo blue by reducing agents, the opposite action by which it is obtained from indigo blue.
4. *Sulphate of Indigo, or Soluble Indigo, Extract or Sulph-indigotic Acid*, $C_{16}H_{10}N_2O_2 . (SO_3)_2$, a beautiful blue-coloured body, readily soluble in water and most dilute acids, and converted into *isatin* by oxidising agents.

Logwood, or Campeachy Wood.

This important colouring-matter is the fermented wood of *Hæmatoxylon campechianum*, a tree cultivated in various parts of South America, in Jamaica, Cuba, etc. The wood reaches this country in the form of logs, which possess but little colour, except on the outer surface exposed to the air. The dye-ware is prepared by the "logwood-grinder" for use by being rasped or broken up into small chips by machinery, and the subjecting it to a "fermentation" process. This consists essentially in exposing the ground wood to the prolonged action of a moist, warm atmosphere, being left in heaps on a wooden floor for two or three months, with occasional raking or stirring up. The object of this treatment is to oxidise or develop the colouring principle contained in the wood, and to render it subsequently easier of extraction, whether in the dye-bath or in preparing "extracts" from it. After fermentation the wood is generally ground in a mill to the desired fineness, and is ready for the market, either for use in the dye-beck, or for conversion into logwood liquor or extracts for use in printing.

Extracts of logwood are made by boiling with water, under pressure, the wood as above prepared, allowing the solution so obtained to stand, to settle impurities, and evaporating the clear liquid down to the desired strength, at as low a temperature as possible, or *in vacuo*. The preparation of good extracts of this and similar vegetable dye-stuffs is an operation requiring considerable skill and capital, but without such extracts those dye-stuffs would not be applicable in printing.

Ground or chipped logwood, as it occurs in commerce, resembles coarse sawdust coloured red, and of damp feeling from the presence of a varying amount of water. It is used for dyeing-up blacks, etc., upon printed-on mordants, and is added directly to the dye-bath. On adding it to cold water part of the colouring principle dissolves out, giving the water a slight buff tinge; on warming more dye is extracted, and the solution becomes deeply coloured reddish. This solution dyes up cloth, properly mordanted with iron or chrome, deep black,—with alumina, red,—with tin, purple,—with copper, violet; and these are the colours obtainable in printing and dyeing by the use of logwood; but now only the black is resorted to—the others being poor shades.

Extract of logwood consists of aqueous solutions varying from 12° Tw. upwards, or pastes varying from 60° Tw. upwards, is deprived of water altogether, and is solid. It is used in the production of black, the mordant being either iron or chrome; it is often used in conjunction with bark extract, a deeper black being obtained.

The colouring principle in logwood is named *hæmatoxyline*, which, when carefully separated in purity, is found to crystallise, of yellowish colour, soluble in hot water, and yielding the reactions already described above, and of a composition represented by the formula $C_{16}H_{14}O_6$. It is an acid body, uniting with alkalies to form colourless hæmatoxylates of soda, etc., but which readily absorb oxygen from the air, and become violet or blue.

Barwood.

This is one of the so-called "hard" red woods grown in Western Africa. It is employed in the production of a bright and fast red on cotton yarn, named "mock turkey kid." The yarn is mordanted first with tin crystals, then with sumac, and dyed at a boiling temperature with the ground wood. Its colouring principle is probably identical with santalin, $C_{15}H_{14}O_5$, contained also in Sanders wood. This body is a fine red crystalline substance, insoluble in cold water, slightly soluble in boiling, but readily dissolved by alcohol, ether, and acetic acid; alkalies also dissolve it, to a violet liquid, thrown down again by acids.

Barwood is not employed in cotton printing, as there is no method known of obtaining a convenient extract of sufficient concentration.

Camwood,

or Kambe wood, is used in woollen dyeing. It differs but slightly from barwood; the colouring matter is more readily dissolved out by water, and the shade of red obtained from it is of a yellower tinge than that obtained from Brazil-wood. It is used in woollen dyeing for producing fast reds and brown, and also for bottoming indigo and aniline blues.

Santal wood, or Sanders.

A hard red wood, brought from India, and used chiefly in woollen dyeing. It yields similar shades to barwood.

Peachwood (Brazil-wood).

A soft red wood, imported chiefly from Campeachy and Brazil—hence the names—from a species of *Cæsalpinia*. It is employed in dyeing imitation cochineal crimsons, both on cotton and woollen goods; it is also largely used, in conjunction with garancine, to produce a brighter red.

Peachwood in the log is, like logwood, almost colourless, and, before being put on the open market for dyers, is rasped and oxidised by long exposure to air and moisture—whereby the colouring matter is developed or rendered more readily extractible—the wood becoming of a bright red colour. On treating peachwood with water, hot or cold, a bright red liquid is obtained, which dyes-up cloth, properly mordanted with alumina and tin, red.

In using peachwood along with garacine, the rasped wood is added directly to the dye-beck along with the garancine.

Orchil (Cudbear).

This once important, and yet not inconsiderable dye, is the aqueous extract of lichens, chiefly the sea-coast genus *Roccella* (species *tinctoria*) and the land lichens of the genus *variolaria*. The commercial article, orchil liquor and paste, cudbear and French purple, is obtained by treating the whole lichen plants with ammonia and water at a temperature of about 40° C., and with proper access of air. Orchil liquor may also be obtained by extracting the plants with boiling water, filtering and heating with ammonia.

Orchil is used chiefly in woollen and silk dyeing; it gives, with these fibres, bright-red or violet-red. It is often employed in conjunction with cochineal. It is not now employed in calico printing, but in woollen printing it is used in browns, blacks, and yellows.

THE FACTORY OR MILL HAND AS A TECHNICAL WORKER.

THE ORGANISATION, GENERAL DUTIES, AND SPECIAL WORK OF THE STAFF OF FACTORIES FOR THE PRODUCTION OF SPUN AND WOVEN GOODS—THAT IS, "YARN" AND "CLOTH"—AND THOSE CHIEFLY IN COTTON AND WOOL.—GENERAL DESCRIPTION OF THE VARIOUS PROCESSES OF MANUFACTURE.

CHAPTER XII.

Practical Points connected with the Rollers of the Drawing Frame (*continued*).

In very coarse spinning mills the "finishing jack" is dispensed with, and then the mule becomes the finishing process where drawing is done. When imperfectly drawn at the drawing frame it is never corrected, although it be drawn and doubled and redrawn and redoubled in the succeeding frames, as above named. Hence the necessity for insuring good drawing at the drawing frame if good yarn is desired.

We have said that when the rollers are too far apart the sliver as delivered is thick and thin; this defect in drawing can only be detected by those accustomed to the work, and so can only be remedied by them. Again, if the front rollers are too near to each other, there is another defect in drawing. This is readily detected by the practical worker. It not only shows its defect by being unevenly drawn, but it comes through in long thick lengths—strictly speaking not drawn at all. The term "spew" is used in some cotton districts when it comes through the rollers in this way. Two other evils, besides that of being so uneven, are attendant upon it. First, the staple of the cotton being too long for the distance between the rollers, both rollers having hold of the staple—*i.e.*, one roller at one end, and the other the other—both rollers being heavily weighted, the staple must of necessity be considerably damaged, therefore the finished yarn will be also damaged in proportion. Secondly, the top rollers being covered with cloth and leather, they are also damaged, and made unfit to work after the rollers are so adjusted as to make the drawing as perfect as possible. Both conditions of the rollers — the distances too short and too long between — are injurious to the preparation of the cotton, and must of necessity be injurious to the finished thread or yarn. Independently of injury which may arise to any part of the machinery by irregularities in the working of the material (the cotton), they are but of little moment to that of the reduction of it in the value of the finished thread. Much damage is often done to both the cotton and the machinery—more from carelessness than want of judgment.

All practical men know the importance of having the rollers fixed or set at such a distance that the staple of the cotton is not damaged (broken), and that they should be so adjusted that the sliver as it leaves the rollers should have as even an appearance as that of a cobweb or that of a sheet of writing paper. This being accomplished at the drawing frame, the cotton in all the other processes will be more completely managed. This attention to the drawing is required at every fresh mixing of cotton, as it is being carried through. Where the same class of yarn has to be produced, the same class of cotton is purchased—*i.e.*, the same length of staple is produced, or should be; but it is impossible to succeed in this at all times even with the very best of judges in cotton, and hence the continual necessity for being on the alert.

The fibres of cotton are of various lengths, and therefore no purchaser of cotton can at all times meet with the exact length. This makes it all the more essential to watch each and every purchase of cotton, when at this particular stage. In setting the rollers of either a drawing frame or any other frame where the cotton has to be drawn, a gauge is used, so that the whole line of rollers can be fixed at the same distance as the first. Having found the right distance for the first head of drawing rollers, the two following heads will require to be set at about the same distance. This being accomplished, a great and important part is performed in the drawing of the cotton, while in a rude and in somewhat entangled and irregular condition, to a state of parallelism and order.

The Stop Motion of the Drawing Frame.—Automatic Arrangement.

The drawing frame is provided with what is denominated a "stop motion." It is an ingenious arrangement; the sliver passing over a spoon which is a little short of being balanced, but is kept in what is practically a balanced condition by the sliver passing over it. But when the sliver breaks the spoon alters its position, and the bottom end of it comes in contact with a rod, and the rod having notches screwed to it, the extreme end of the spoon as it alters its position comes against the notches and causes the rod to stop. This rod has a catch-box at one end of it, and is then thrown out of gear, and thus comes in contact with the strap rod, and the strap rod is moved from the position of the fast or driving pulley to that of a loose pulley; thus the part stops and remains in that position until the "tenter" makes the broken part good, and then the driving strap is drawn on by the attendant by hand. This stop motion is now of such value that it is attached to all new frames. It prevents singles: *i.e.*, where six ends are run up, and one breaks, if the frame did not stop of its own accord it would continue to run with five slivers instead of six, and would thus be spoken of as "running single." "Running single," in cotton workers' phrase, means when any piece of work is short of its full quantity. In all the following frames, except that of the slubbing frame, two ends run into one, and in such case if one end breaks, the one which is left is truly "single."

The cotton as it leaves the carding engine is in the state of a delicate, flat, riband form, called a sliver; the fibres are thus in a state of entanglement—*i.e.*, cross each other, some pointing to the north and others to the west or east. One consequence of the drawing process, if properly conducted, is that the drawing is perfectly equal in thickness in every part, and formed of parallel fibres; and in order to make it so far perfect, the drawing is repeated more than once, and the doubling is repeated more than once, in order to obtain these most desirable objects, parallelism of the fibres and evenness of the sliver. As we have before stated, this "drawing frame" is in its mechanism simple; but although simple, it is of such importance to the cotton spinner as to be indispensable.

The Slubbing, or Roving, the Next Process of the Cotton Manufacture after the Drawing.

The preceding paragraph was taken up with a description of the "drawing frame," and notes on the general management of its work. We now come to the consideration of the machine next in sequence, which is known as the "slubbing frame"; why so called it is difficult now to ascertain. This name gives not the slightest indication of the character of the work which it performs, since this work may be said to be the first approach to the spinning of the fibres into a "thread," or into "yarn" as the technical term is for spun fibres. We say that the work of the slubbing frame is an approach to the process of spinning. This may be here popularly described as the "twisting" or "twining" of the fibres together, so that they have such coherence or strength as will up to a certain point resist any pulling strain calculated to tear them asunder. A very slight consideration of what this twisting, twining, or spinning of the fibres is, will show that the operation will be all the more complete as regards the ultimate strength of the twisted, twined, or spun fibres—and all the more uniform as regards diameter or thickness—if the fibres, before being spun, are placed parallel to one another, and the short ones placed alongside of the long ones, so that a long continuous riband or "sliver" is produced. It is this condition which it is the aim of the drawing frame described in the paragraph preceding this to produce. And if the reader has carefully studied what we have said as to the process of "drawing," and the machine ("drawing frame") which effects that process, he will understand how very important it is that the drawing should be thoroughly done. So important, that the operation of "drawing" the cotton fibres, and of "doubling" them, which is an inherent part of the process of drawing, is also carried out in the machines which perform other and advanced work, and to the description of which we now address ourselves.

Thus, in the "slubbing frame," which is the first of the advanced machines we notice, while one part of its work is the twisting of the fibres into a species of coarse yarn, "drawing" also constitutes a part of it. And in the machine next following the slubbing frame, drawing is still done. The reader will thus perceive that, this being the case in the machine following the slubbing frame, what "twist" or degree of twining the fibres together is given to them by the "slubbing frame" *must be again taken out of it* before the "drawing" process can be effected in the machine which follows. The twist, or degree of twining or spinning, then, given to the fibres by the slubbing frame, is in fact only given to them to afford them for a time such coherence or strength as to enable the attenuated sliver to be taken through the process and advanced to the next machine—in which "drawing" is still required to be done.

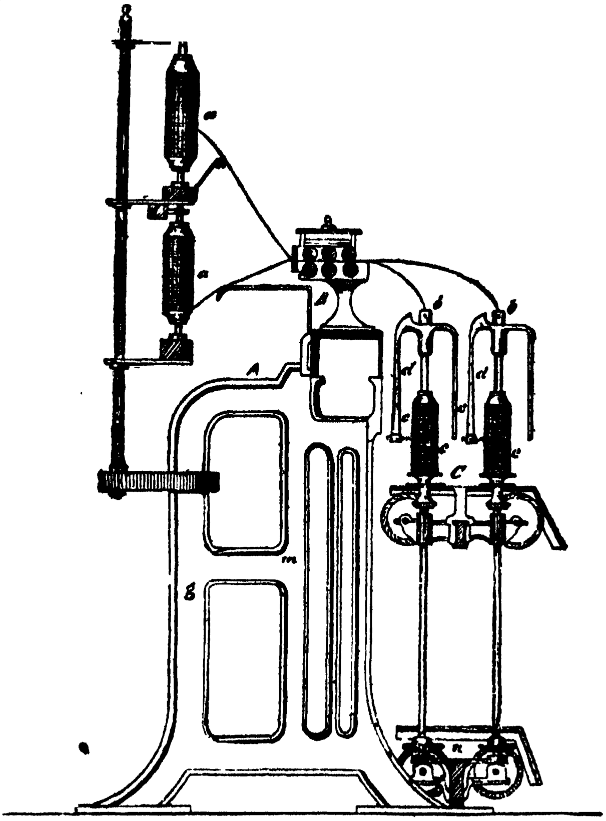

Fig. 10.

The Slubbing Frame.—The "Bobbin and Fly" Machine.

Of the many slubbing machines which have been invented, the one most generally used is that in which the "bobbin and flyer" are the principal features. This machine is represented in fig. 10.

THE SANITARY ARCHITECT.

THE PRINCIPLES AND PRACTICE OF HIS WORK, IN HEALTHY HOUSE ARRANGEMENT AND CONSTRUCTION.—TECHNICAL POINTS OF SEWERAGE AND DRAINAGE, VENTILATION, ETC.

CHAPTER VII.

The Primary Perils of House Drainage Work: Careless Work (*continued*).

IN last chapter under this head we stated that we admitted that multiplicity of systems have had a prejudicial effect on the practice of house drainage; but while admitting this, there can be no doubt that the real mischief has been done, not merely in the retardation of true progress, but in the perpetration and perpetuation of bad systems wholly through the careless work of those to whom their execution was intrusted. We have said careless, but truth compels us to characterise it as dishonest work. It is unfortunately but too true, in the practice of all classes of constructive work, that concealed work—that is, work which, when finished, is not open to inspection—is in great danger of being "scamped" or carelessly done, and in but too many cases not done at all. The temptation to do this seems too great to be withstood by many men: the mere fact that no one will be able to see whether the work is well or ill done seems to decide the matter, and against the interest of the party requiring the work; so that the ill-done is deliberately preferred to the well-done work. This is bad enough; but matters are much worse when the work is not done at all. How this is brought about we shall see when we come to the practical details of house drainage. Meanwhile we draw particular attention to this point of working-life morality, as one which affects in the closest manner the whole question of practical house drainage,—it is scarcely necessary to say, all classes of work, indeed. To talk of those who, concerning concealed work, or work which is finally covered up, can bring their minds to the doing of bad work, or to the not doing of it at all, simply because it will not be found out, as being unable to withstand the temptation to do dishonestly, is in fact a wrong way of putting it. For the truth is, that with the majority of such people there is no temptation to be withstood—that is, struggled against. Struggling with it involves the idea of conscience being in some way concerned in it, as not being altogether drowned; but with them there is no struggle, because there is no doubt: the doing of wrong simply because the wrong is not likely to be found out is simply a matter of deliberate choice. We have said that this low *morale*—or condition in which there is no truth, no morality, at all concerned—has had a most baneful influence on the progress of house drainage; for there is perhaps no class of constructive work which admits of so many and ready opportunities of "scamping" work as this one. Nearly every detail of it is, from the very nature of the circumstances, concealed or covered over when the whole system of house drainage is completed. It often happens, in giving the concrete form of a word, phrase or proverb to some form of immorality or evil doing, that the word or phrase chosen glosses the evil over and tries to convey the idea that it is not so bad as it is. We could cite many instances of this, as now embalmed in our language; and where they exist they show a still lower *morale*, and a more decided determination to call evil good, and a still greater liking for it in preference to the good. But in the case we have under consideration, the very name given to the practice of doing bad work because there is the opportunity afforded to do it without being found out shows that there is still some consciousness of its evil. For when we talk of "scamping" or "scamped" work, we at once convey the notion that we know it to be the work of a "scamp"; and it is needless to say what is the degree of estimation in which he is held by honest people.

House Drainage Work.—Moral Considerations connected with it.

There are those who maintain that considerations of morality should never be mixed up with those connected with technical work, or work of any kind. We are well aware that this principle is acted upon largely in every-day life, so that it is no uncommon thing to hear an employer say, 'What manner of men my hands are, whether they be good or bad, matters nothing to me.' If he knew what constituted his best interests he would see that this mattered everything to him. But the fact is that even such employers, in the conduct of their business, show that the character of those they employ is a matter of the greatest practical importance to them. They do not put—never dream of putting—into situations of trust the depraved and the worthless: they place no confidence in men of this class; and if they were asked pointedly what would be the result if their business were carried on by men all of whom were of high *moralè*, with whom their word was as good as their bond, they would have but one reply to make—that their business would be infinitely more profitable and vastly more pleasant to carry on. The truth is that we cannot, if we would, separate the moral attributes from the man considered as a mere worker. We must take men as we find them, the facts of human nature as they are everywhere and everywhen presented to us. And the more fully we take wise advantage of this, the more satisfactory shall we find our work done, simply considered. Work done conscientiously must be good work: better work, at all events, it must be than that done by those who are merely thinking of getting the time over which must be devoted to work of some kind or another, and bringing on as quickly as possible the time when the work, such as it is, is to be paid for. Men who think more of pay-day than of the class or high character of the work which secures its reward never do, never can, give the best work. Such considerations lie at the very root of all work; and the truth is incontestable that unless we pay more heed to them in the future, we shall make as little progress in true technical education as we have done in the past. When such considerations are taken into account we shall see on the extended scale what is now unfortunately met with on a very limited one,—men of all grades rising to a knowledge of the dignity of labour and all the elevating influences which that dignity involves. The writer of these lines has had much to do with technical workmen; he knows also of the wider experience and the higher knowledge of others who have had more; and from all he knows and has seen, he is impressed with the most profound conviction that technical education will not bring with it all the advantages which it is capable of giving to us as a people, if these be not united with an earnest endeavour to raise the moral attributes of our students to that high pitch which just in proportion as it will make them good men will make them good workmen. The sooner we come nationally to the conviction that it is not so much what a man knows as how he uses his knowledge, the better it will be for us as a people.

Precautions to be taken in carrying out House Drainage Work.

Meanwhile, seeing that "scamped" work is being done daily, and done most extensively—those who have the best means of judging say that it is the rule, not the exception, where it can be done without being found out—every means must be taken to see that the work of house drainage is not only actually done, but done in the most thoroughly efficient manner. It is not enough that the owner of the house shall intrust the care of its drainage to his builder—unless, indeed, he has the good fortune to have a builder of the highest position and *morale*. For there are builders *and* builders; and some of that class, not of the highest in *morale*, have been known to do, or rather instruct their workmen to do, such a piece of dishonest work as to take the drain leading from the house only so far on its way to the street sewer, but to stop short of that—thus allowing the sewage to soak into and saturate the soil in the immediate neighbourhood of the house, very possibly right under some window, thus forming a source of sewer gas infinitely more dangerous than the old-fashioned cesspool, which at least possessed this advantage—that its existence was known, its position marked and defined. Work as bad as this now noted has been again and again done by dishonourable builders, into whose hands none of our readers proposing to build will, we hope, fall. It is not enough, in order to secure his house drainage to be the reality of a well executed and therefore efficiently working system, that the owner should trust to his architect. As a class architects are without reproach, and would tolerate no scamping work, or even an approach to it. But the architect cannot be always present; it is practically impossible that he should actually see for himself how all work is done and all details are efficiently attended to. No doubt he will be represented by the clerk of the works; but it is not every house which is so important as a "job" that it will justify the having of this official. And even where it can afford it, as there are builders *and* builders, so there are clerks of works *and* clerks of works, and some have been known to be not only careless about their work, indifferent to their duties, but so dishonest and dishonourable in their relation to their employers, that they have winked at work being badly done, or, worse than this, have allowed it to pass as done when it was not done at all. Thus placed, it would appear, therefore, that the owner of the house must depend upon himself to see that the work of the drainage of it is really well done. This seems to throw a burden upon him which should be borne by some other or others. It also involves the possession of a knowledge of technical details which does not come within the range of the acquirements of men engaged in ordinary business, or perhaps in no business at all. Further, the owner of a house, although quite capable of looking after work and judging whether it were well done, might object, and reasonably enough looked at at first sight, to doing work of this kind, which ought in all fairness to be done by others. But there are few men, however much engaged, or whatever their position, who would grudge the time necessary to give instructions about or pass an opinion upon the purely decorative work of the rooms of his house, or the laying out of his grounds. And seeing this, while by no means ignoring the claim of those departments to great attention, it surely cannot be denied that the health, not only of himself, but of his household, is a matter demanding at least an equal amount of care and attention. Viewed rightly, health is essential, decoration only an accessory of life, important as that accessory is. And there can be little doubt of the fact that the healthy condition of a house is largely dependent upon that of its drainage. What has been given in preceding chapters has been given to little purpose if readers who may be proposing to build themselves houses (see the papers entitled "The House Planner") are not convinced of the truth of this. Failing any personal exertion on his own part in seeing that the drainage of his house is well executed, the owner should at all events call in the aid of a trustworthy sanitary inspector to report on its condition.

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